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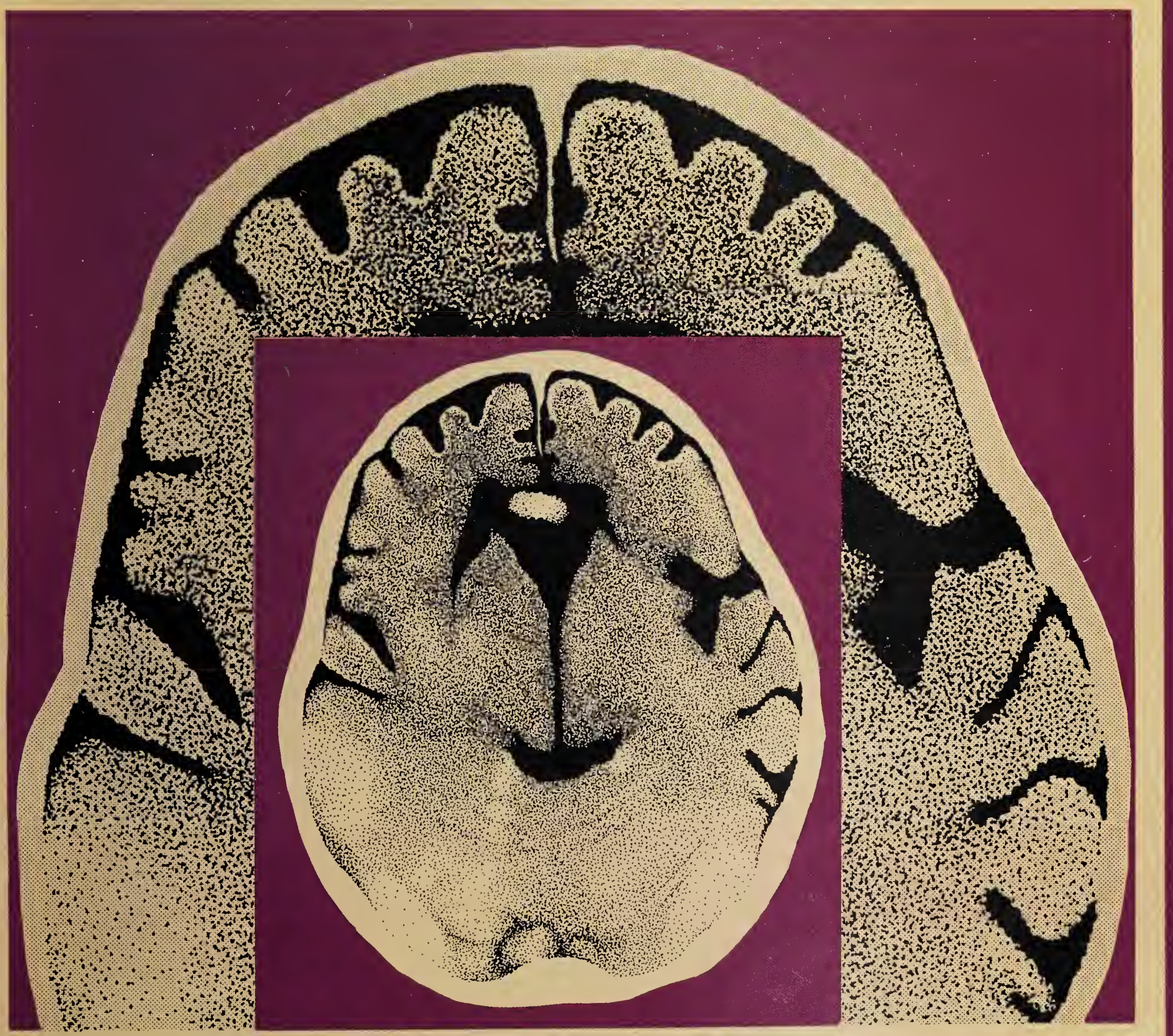

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- New Techniques in Radiology
- Radiology Rounds
- Nuclear Medicine
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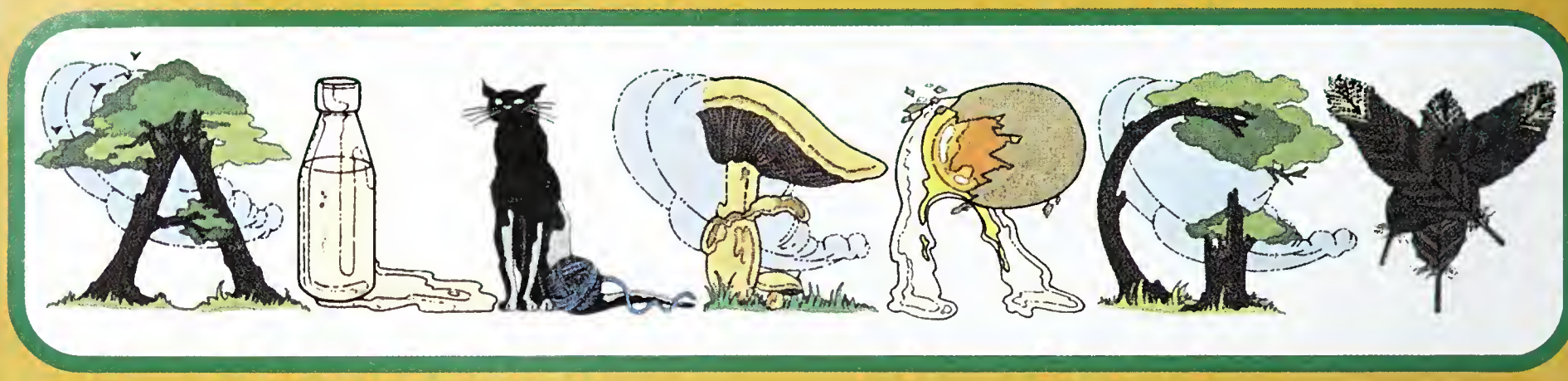

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If you are interested in serving on the Executive Committee, or would like to have your opinions voiced to the proper authorities, please do not hesitate to contact YOUR Medical Alumni Association.

Above all, consider it an honour to be invited to attend the Medical Alumni Association and to help those who are coming after you.

MEDICAL ASSOCIATION ALUMNI

Editor's Message

The main theme of this the second issue of the 62nd volume of the *University of Toronto Medical Journal* focuses upon recent technological advances in medicine. Our feature article by Dr. Kenneth Taylor, Associate Professor of Radiology, discusses developments in the field of Diagnostic Imaging and Interventional Radiology with an interesting introduction to one of the most exciting new techniques — Magnetic Resonance Imaging (nuclear magnetic resonance). Other articles discuss research on a new therapeutic technique in Neurosurgery and a new diagnostic technique in Nuclear Medicine.

Dr. Weisbrod, Staff Radiologist at the Toronto General Hospital, presents a diagnostic challenge in the Radiology Rounds of an unknown mediastinal mass. Other articles in this issue range from pediatrics to orthopedic surgery.

Vincent W.S. Lai
Editor-in-Chief

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1. All articles intended for publication should be submitted to the editors before the deadline which is usually six weeks before the release of the Journal.
2. Submitted articles should be typed (or legibly printed) double-spaced, single-sided on paper 8½" × 11" (letter size) and they should not be more than 20 to 30 pages (5000 to 6000 words).
3. Illustrations, graphs, diagrams and figures should be put on a separate sheet and identified by Arabic numerals. A list of explanatory legends for all the figures and diagrams should be put on another sheet. Do not write on the back of photographs.
4. References should be checked with the original sources, designated by raised Arabic numerals in the text, and listed in alphabetical order on a separate sheet. Each periodical reference should include in order: the author's last name and initials, title of the article, journal name, volume number, page number, and year (e.g. Risser JC: Scoliosis: Past and Present. *J. Bone and Joint Surg* 46 A: 167, 1964). For further information please consult the MLA Stylesheet.
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New Techniques in Radiology

Ken Taylor, Ph. D.,
Associated Professor of Radiology,
Director of R. B. Holmes Radiological Research Laboratories,
Department of Radiology,
University of Toronto

Radiology has changed dramatically over the past 15 years and now employs some of the highest technology in use in our society. The modalities for producing images of tissues are numerous and radiology encompasses not only diagnosis but also investigation, research and therapy. This article reviews what was happened and describes in more detail three of the many advances now in progress.

Introduction

In the 1970's the relatively stable discipline of radiology exploded into vigorous activity and experienced several radical advances which continue unabated to this day. These advances were born out of the major developments in solid state physics, electronics and computers occurring in the late 1960's as a result of the big 'push' in the space and communication fields. The excitement over the advances was intense and competition amongst manufacturers and hospitals to provide and obtain the 'best state of the art' machines has been extreme. The competition now extends to the particular modality by which imaging will be achieved. For example, the modalities include not only the use of x-rays in computerized tomograpy (CT), in digital fluoroscopy and fluorography, and in digital radiography, but also the use of nuclear radiations in single photon emission computed tomography (SPECT) and in positron emission tomography (PET), the use of ultrasound in various modes, the use of nuclear magnetic resonance in magnetic resonance imaging (MRI) and the use of light transmission through tissues (transillumination). Truly an explosion compared with the state of radiology in the 1960's.

Of course, there has also been an explosion in costs, with many of these imaging devices costing in excess of $1 million to purchase and in excess of $250,000 a year to run. The number of patients, on the other hand, is limited to 10 per day (2,500 per year). As a result, the strong arm of bureaucracy now rests heavily on the discipline of radiology, even though these new techniques often can be shown to bring about a substantial saving in the number of hospital bed days needed for evaluation of the patient's condition.

Traditional radiological imaging has been sucked into this rapid expansion, and high sophistication is found in all new x-ray equipment, including massive rotating mountings for x-ray imaging systems which permit the viewing of the patient's organs from any direction, and a high degree of automation and computerization in the imaging process. Again a cost of over $1 million for an angiographic machine is now the norm. Medical imaging has been a veritable bonanza for our commercial colleagues. Yet high development costs and extreme competition can lead to the demise of industrial giants such as the developer of the CT scanner, EMI.

This turbulence in imaging has led to some exciting offshoots for clinical therapy. For example, defects in arteries and tumours may be approached by catheters inserted into arteries under fluoroscopic guidance, and the catheters may then be used to effect therapy. Arteries can be expanded when blocked, and can be blocked when bleeding. Tumours can be infused with toxic drugs. Arterial walls can even be viewed through fibre optic catheters (angioscopy). Such interventional radiology may greatly reduce the need for complex surgery and the lengthy hospital stays it requires. Indeed, interventional procedures are now being carried out on an out-patient basis.

Many of these new imaging modalities open up new avenues of research in medicine and health care. PET imaging permits biochemical studies of metabolism in the brain and other organs. MR imaging also shows tremendous potiential for biochemical studies on organs, even down to changes occurring in atomic binding of certain elements. Unforunately academic research in radiology has lagged far behind research in other disciplines and the potential of these new imaging modalities as research tools has yet to be fully exploited. The establishment of imaging centres in the U.S.A. has proceeded rapidly over the past ten years but, with a couple of notable exceptions, has only recently started in Canada. In Canada the mechanisms for funding such expensive research facilities over a sufficient period of time hardly exist, since most grant funding is disease or organ oriented rather than technique oriented and grants lie in the hundreds of thousands rather than in the millions.

With this brief survey of advances in medical imaging, I will now leave the general for the specific. Clearly we can-

not review all the modalities we have mentioned and so I will concentrate on three advances which are most likely to come to your attention in the field of medical education and research. This does not indicate that other modalities are of less importance, only that they are more specialized or in a slower phase of development. The three advances are digital x-ray imaging, interventional techniques and magnetic resonance imaging.

Digital Imaging with X-rays

Digital imaging in radiology started with CT scanners in the early 1970's.[1] The transmission through the body of a pencil beam of x-rays was measured over a narrow cross section of the body and for all angles of incidence to the body. Each measurement was recorded as a digital number accurate to 1 in 10,000 and hundreds of thousands of measurements were made over each body section. A computer was then used to reconstruct the attenuation of the tissues in the body section and produced a digital image which showed not only the cross section of bones, fat and air, the tissues usually seen in radiographs, but also subtle differences in tissues never before seen with x-rays, such as grey and white matter in the brain.

Essential to this technique were methods for fast and accurate digitization of signals from detectors, which were very linear and had high signal to noise ratios, and computers which could store the multitude of measurements and rapidly carry out the millions of calculations necessary to rebuild the cross sectional image. The progressd which has been made in 10 years can be seen in Fig. 1a and b. The number of measurements per image has gone from 100,000 to over 1 million and scan times and computation times have dropped from minutes to seconds, resulting in instantly available images of outstanding quality. This has been truly the greatest advance in medical imaging since the discovery of x-rays in 1895.

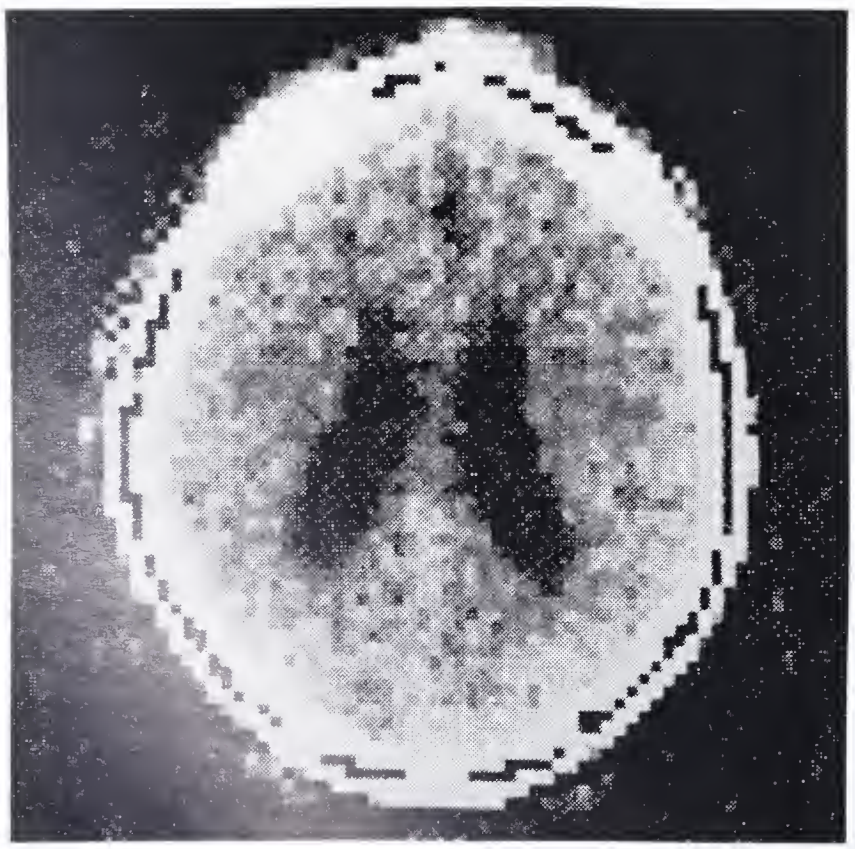

Figure 1a. Early CT scan of a bran made with an 80 × 80 pixel matrix, showing the ventricles.

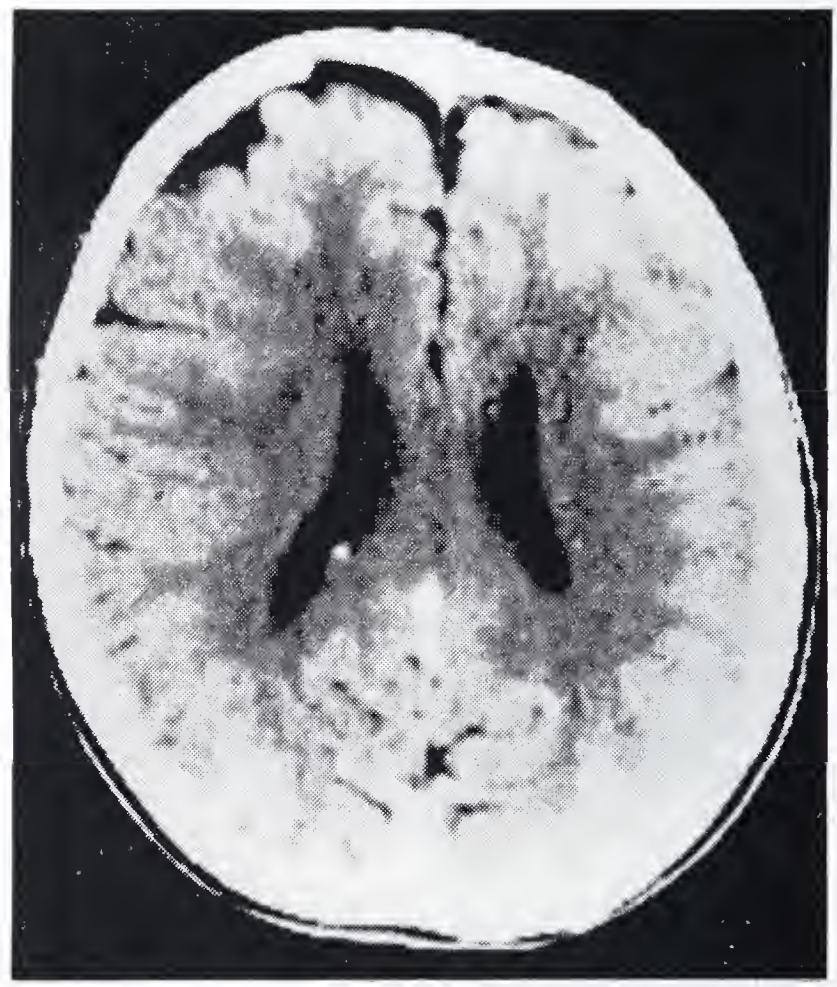

Figure 1b. Recent CT scan of a brain made with a 512 ×512 pixel matrix, again showing the ventricles but also differentiating grey and white matter and showing considerable detail of the structure of the brain.

Figure 1c. Recent MRI scan of a brain, showing the ventricles and great detail of the structure of the brain. Note that the skull appears black instead of the white in the CT scans; the outer ring of white is the scalp (a and b courtesy of General Electric Medical, U.S.A.).

To digress for a moment, it is humbling for all of us to note that the inventor of the CT scanner, Godfrey Hounsfield of EMI Ltd., U.K., had no experience in the medical field before his invention, was an outstanding computer technolgist rather than an eminent scientist and carried his invention to the market place in spite of some skepticism. All this adds to the eminence of his work. Of course, his invention led to a profusion of honors — the Noble Prize for Medicine,[2] Fellow of the Royal Society, a knighthood, and a multitude of honorary degrees and awards including the Gairdner Foundation Award in this University, the first honor to actually give him a significant financial award. It is also interesting that Sir Godfrey Hounsfield, as he became, declined to leave the security of his parent company for the enticements of North America but within a few years was faced with the disintegration of EMI. All of which points out again the place of serendipity in major advances and that the best laid plans of mice and men often go astray. Whilst our society depends upon the expected for its stability, it is the unexpected which often leads to major advances. Researchers and granting agencies take note. Also note that inventors of subsequent new imaging techniques have not received the same acclamation as Dr. Hounsfield and therefore if you wish for fame and fortune perhaps you should try another field!

To return to digital imaging, Hounsfield's success encouraged others to examine the potential for digital and computer techniques. It became evident that there was more information in x-ray images than could be seen in the usual images on film or on a television monitor during fluoroscopy. This information could be made visible by digital and computer processing of the images.

The first new digital techniques was introduced in the late 1970's by Mistretta at the University of Wisconsin Department of Medical Physics. This was *digital video subtraction fluoroscopy*[3] and was aimed at permitting angiography with intravenous injection of contrast medium, for which the concentration of contrast medium was too low to be seen directly on a fluoroscopic image, but could be seen if the contrast in the images was greatly enhanced. Unfortunately, contrast enhancement also enhanced all the background structures and still did not permit clear visualization of the artery along its whole length. In Mistretta's machine, which used conventional fluoroscopy with an image intensifier and TV chain, a single TV image was digitized and stored before the start of injection of the contrast medium. This is called the mask image. All subsequent images were subtracted from the mask image as they were generated, point by point in each image. The subtracted images, no longer containing background structures but only the difference in the images due to the injected constrast medium, were now contrast enhanced to give a clear view of the arteries as seen in Fig. 2. Mistretta had previously shown that this could be done with analog recording and subtraction techniques but with substantial recording artefacts which are not present with the digital techniques.

Intravenous digital subtraction angiography (IVDSA) using digital subtraction fluoroscopy created a lot of excitement in the early 1980's. Angiography with intravenous

Figure 2 Intravenous digital subtraction image of the arteries in the neck (carotid and vertebral) with the structure of the neck and head removed by the subtraction of the mask image. Note the relatively poor resolution and mottling of the image.

instead of arterial injections potentially provided a safer and less expensive form of angiography which could be used for screening patients for arterial disease as well as for following the results of treatment. Now, 5 years after its introduction, many manufacturers supply such machines and the technique has a firm place in medical radiology but has not quite met its initial promise because of several disadvantages.[4] It has, on the other hand, led to other new techniques which we will consider in a moment. The disadvantages are: compared with an image on film, the detail in the image is rather poor, limited by the frequency response of the 512 by 512 pixel matrix of the digital image system — a 2048 × 2048 matrix would be needed to achieve the same detail as film; the subtracted images are prone to artefacts due to the movement of the patient between mask and contrast-filled images and due to differences in the images of the contrast filled arteries when they overlie bone and soft tissue; the quantity of toxic contrast medium required is still as high as in arterial angiography; problems with damage to arteries in arterial angiography are replaced with problems of damage to veins and injection of the contrast medium into surrounding tissues; radiation exposures in early machines were rather high and the risk of harm due to the radiation prevented the use of the for technique screening; finally the digital systems added

several hundred thousand dollars to the cost of an angiographic machine. Slowly but surely these problems are being overcome but it has not prevented the return to the manufacturer of machine because their performance was considered inadequate or inferior to existing arterial injection angiographic techniques. It is interesting to note that in Toronto the technique has been adopted sooner and more readily in peripheral hospitals than in the major teaching hospitals, where the usual intra-arterial angiography is considered essential for the patient, whatever the outcome of the digital studies.

Digital fluoroscopy has now evolved in a number of different directions, all of which may find application equal to or greater than the original. I will describe three developments. Firstly by summing consecutive TV images, which are normally produced at a rate of 30/sec, the noise in the fluoroscopic image may be significantly reduced.[5] Since this noise arises largely from statistical variations in the small number of x-rays being absorbed in the imaging system, a sort of 'raindrop pattern', a reduction of the noise by summing of images means that the x-ray exposure rate during fluoroscopy can be reduced without loss of image quality.[6] Since fluoroscopy is a major contributor to the x-ray exposure of patients and gives rise to a very small but still significant risk of x-ray induced cancer, such methods of x-ray exposure reduction are worthwhile, especially as the new interventional techniques require extensive fluoroscopy. An extension of this technique permits one to obtain an image with a single bursts of x-ray and then replay it for a fraction of a second until a new burst of x-rays produces a new image. In this way additional reduction of x-ray exposure may be achieved. Variations on this theme also permit one to record a bolus of arterially injected contrast medium travelling down an artery and to integrate its image as it travels.[7] This avoids the necessity of filling the whole artery with contrast medium at one time and reduces by a substantial amount the quantity of toxic contrast material required. This is referred to as *vascular tracing*. This traced image of an artery superimposed on a fluoroscopic image can help with the insertion and positioning of catheters.[8]

The second development is perhaps one of the more important at the present time and is called *digital fluorography*. With special TV systems it is possible to digitize and record single TV images instead of continuous images at 30/sec. The x-ray system may now be used, as it is with normal angiography, to take just a few pictures a second for several seconds. With a large digital image memory, many images can be stored and the digital images can be processed after the procedure is completed. With this technique the mask image used for subtraction can be selected in the post processing to obtain a better subtraction with less artefacts. Integration of images to reduce noise can be optimized to include all those images which contain contrast medium.[9] Furthermore images recorded on film can be put into the digital system for processing. The possibilities for image processing are legion and research into these will be ongoing as the technique becomes more widely used.

Such systems have cost over $500,000 but many are now in use. As well as for IVDSA they can be used also for normal intra-arterial angiography, when the subtraction and enchancement features permit the use of lower concentrations of toxic contrast material.[10] The digital stored images can also be used to measure the rate of flow of contrast medium in arteries[11] and the clearance rate of contrast material from organs, such as the kidney. This is of growing interest to investigative studies as well as in diagnosis.

Another potiential of this second development is to take consecutive images with x-ray beams of different penetrating power (kVp and filtration) and, by suitable manipulation and subtraction, to enhance one body component against another, for example enchance contrast medium in the image and suppress bone.[12] This also helps to suppress artefacts in the subtraction images due to movement of the patient.[13] Much research is in progress into this technique.[14,15]

The digital circuits and computers used in these techniques must not only have very large memories (each image requires 250 kbyte) but must also be very fast in processing the image data. Digital magnetic discs with fast access, and array processors, permit almost instantaneous image processing, even when images are recorded and retrieved at 30/sec. Such capacity and speed is now becoming available in a relatively small console which can be easily wheeled from one x-ray machine to another so that it can be used on any machine with fluoroscopic TV. With comprehensive and sophisticated software, this console costs about $200,000.

The third development in digital x-ray imaging is very different from the other two. It is an attempt to record and store all x-ray images, not just those from angiography, entirely digitally rather than on x-ray film, a technique referred to as *digital radiography*.[16] Because of the limitations of resolution set by television systems, digital radiography usually makes use of other types of image receptor or image transducer which can attain higher resolution.[17] In addition, computer memories are configured to accept images with 2048 × 2048 pixel matrices. In this way the resolution of the digital image will approach the resolution of an image recorded on film. This detailed digital image is then recorded permanently on a digital magnetic or laser disc, which can hold on a single disc thousands of images.

The potential advantages of this digital radiology are many. X-ray exposures can be minimized and are not determined by the sensitivity of a film. Images can be processed to improve the visibility of structures. For example, in chest radiography (which is about 50% of all x-ray exams), it is difficult to see clearly at the same time and on one film structures in the lungs and in the mediastinal area because the range of x-ray exposures reaching the film from these two areas is too wide for the film to record at optimum contrast for the eye to see. Digital chest images can be processed to 'flatten' the image (reduce the contrast in low frequency structures) and enhance the higher frequency structures. Digital images can also be transmitted readily throughout a hospital, can quickly and easily be found and retrieved from a disc image store, and the storage space required is a small fraction of that required for film.

As usual the main disadvantages is the cost — perhaps on the order of $5 million or more to provide a basic system in a teaching hospital. But a chest examination costs $4 for the film alone and a large hospital may do 70,000 chest examinations per year. Couple that with the cost of storage, retrieval and transmission of films and the digital systems may prove cost effective within a decade. In any case, such systems are already in an advanced state of planning for a few Canadian hospitals and trail installations will probably be operating within a year.

All that remains is to keep these complex systems operational and this will face most hospitals with the necessity for a major improvement in their approach to the purchase, installation and maintenance of high technology systems. Indeed, it will also demand a significant change in the activities of our physicians, surgeons, radiologists, nurses and medical technologists. Change is achieved with some stress to the participants and the next ten years will involve much discussion and examination of the benefits to medicine and health care from these fairly major upheavals in medical x-ray imaging.

Interventional Radiology

The next advance in medical imaging we will examine is unrelated to the high technology we have just discussed, except that the technology may be useful in the pursuit of the advance[18] and may have stimulated radiologists to a more adventurous approach to their discipline. Remember that the adventurous physician who first catheterized the heart (and created another major advance in medicine) was fired for defiance of instructions not to do so. So perhaps some stimulus was required for the rapid growth of interventional techniques.

Percutaneous catheterization of arteries and arteriography have been with us for three decades and have played a major role in our understanding, diagnosis and treatment of cardiovascular disease, by far the leading cause of death in our society, if not of suffering and disability. Selective catheterization of all the significant arteries in the body, including the coronary arteries, has become commonplace. The method of treatment has been cardiac or vascular surgery, with its attendant high cost, lengthy hospital stay, patient morbidity and risk of death.

Interventional radiology attempts to overcome these problems. Its philosophy is 'if we have to place a catheter tip close to an arterial lesion, why not do something about the lesion while we are there and then look to see if we have fixed it'. The lesions may take at least three forms: atherosclerotic stenoses, bleeding arteries and vascular beds, and tumours served by specific arteries.

Stenoses are widened by a technique called *angioplasty.* Once the position and severity of the lesion has been identified by arteriography, an intra-arterial catheter with a small balloon on the end is advanced to the lesion and pushed into the narrowed area, guided by a wire. The balloon is then carefully inflated and squashes back the atherosclerotic material and the wall of the artery until the bore of the artery is roughly the same as that on either side of the lesion.[19] A typical case is shown in Fig. 3. This tech-

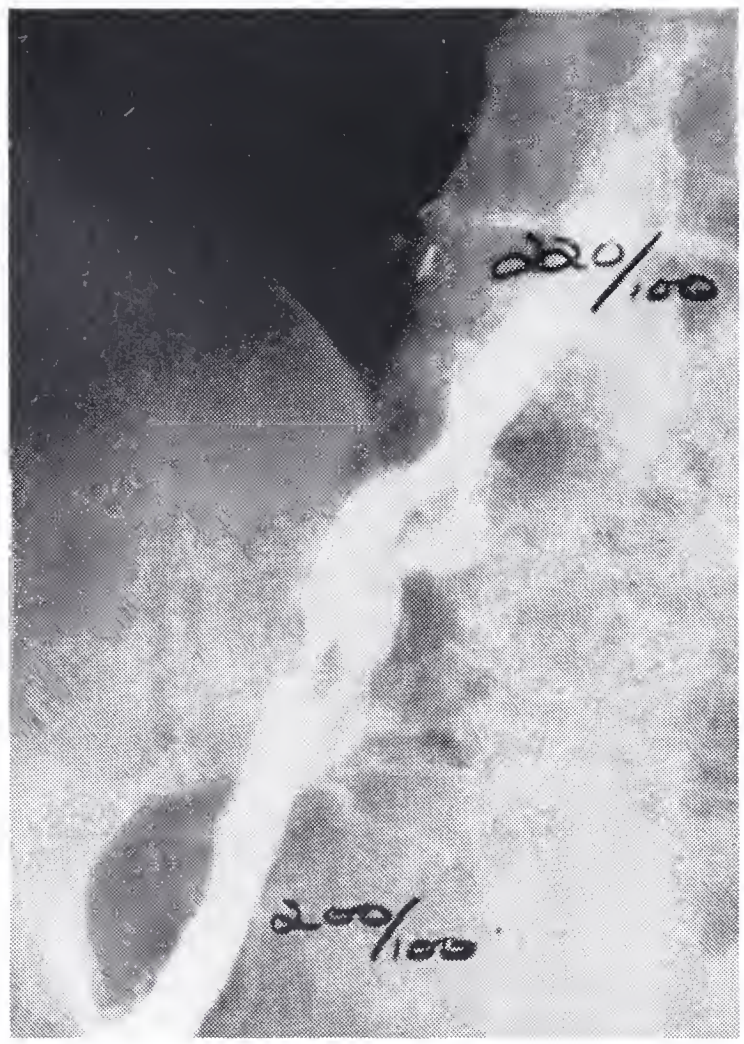

Figure 3a. Angiogram of a severely stenosed iliac artery. The pressures in the artery shown on the image indicate a significant pressure drop across the narrowing.

Figure 3b. After widening of the narrowing with a balloon catheter, the artery appears almost normal and the pressure drop is gone.

nique has had tremendous success, particularly in the major arteries of the abdomen,[20, 22] and is now being applied to the coronary arteries.[23] The advantages of the technique are: no lengthy hospital stay is required for the treatment; the patient morbidity is low and the patient is back to normal activity within hours; complications are minimal and the risks very small. The technique is therefore becoming an outpatient rather than an inpatient procedure.[24, 25] Dr. R. F. Colapinto, formerly of the Toronto General Hospital, who has been one of the leaders in the evaluation and development of this technique, has now set up a private clinic to carry out this procedure on an outpatient basis, since serious complications in his series of patients are negligible. This is a very significant development in the treatment of a serious and common disease.

Just as valuable, and sometimes life saving, is the procedure to block a persistent or acutely bleeding vascular bed, known as *angio occlusion*.[26, 27] The bleeding point is identified by arteriography and the artery supplying that point is then blocked. This may be done with a sealant, like silicone rubber, which is injected into the artery through a catheter and then solidifies, or with a spring or other foreign body introduced into the artery through a catheter, which causes coagulation of the blood.

The third interventional technique is a little more specialized and slower to develop. In the case of tumours, which may be inoperable but which have a fairly well defined arterial supply clearly seen at arteriography, it is possible to infuse through a catheter placed in the artery a volume of cyto-toxic drug sufficient to fill the tumour and do severe damage.[28] The drug is kept in the tumour by blocking the artery as soon as the infusion is complete, preventing any further flow in that part of the vascular system. Thus the drug is restricted largely to the tumour and will not have the harmful effect on the patient normally experienced with cyto-toxic drugs.

These are exciting developments in medicine and promise to make some treatments much less costly, safer and less harmful to the patient. Indeed they may be the forerunners of a much wider use of an interventional and intravenous approach to disease and its treatment. Recently catheters have been introduced which permit, through fibre optics, the viewing of the walls of an artery *(angioscopy)*. One is no longer dependent on x-ray arteriography to view a lesion and the results of treatment. Of course, there are other vessels in the body which may be used to approach organs — the upper and lower GI tracts have been used for many years — and studies of the use of many of these are in progress. Indeed starting from the skin one many create one's own channels through tissues to the target organ, both for biopsy as well as for treatment.

Magnetic Resonance Imaging

Moving away from x-rays, the third advance shaking radiology is in the use of nuclear magnetic resonance for imaging. The word nuclear has now been dropped by radiologists because of its association with bombs and dangerous radiations. It is beyond the scope of this review to describe the physical principals in detail [29, 31] but a brief description will illustrate the potential of the method.

The spinning charge in a proton makes it a minute magnet. In atoms composed of a number of protons these magnets oppose each other and the resultant magnetic moment will be weak. However, if there is an odd number of protons and neutrons, as in P31 or Na23, then a significant residual magnetism can remain. The strongest magnetic moment is found in the single proton, or hydrogen nucleus, a dominant component of the water in the human body. Normally, these minute magnets are oriented randomly throughout the body under the influence of thermal agitation and there is no magnetic moment associated with the body. However, if the body is placed in a magnetic field B the proton magnets will turn to align with the field. Although thermal agitation still maintains a distribution of orientations for the individual protons, there is now a resultant magnetic moment M in the body in the direction of the field B, Fig. 4a. When the field is removed thermal agitation returns the proton magnets to a random orientation.

Figure 4a. Resultant magnetic moment M due to partial alignment with the applied field B of individual proton magnets, which still point in different directions because of thermal agitation.

If, while the field B is applied to the body, a radio-frequency(RF) electromagnetic radiation with its magnetic component B^1 perpendicular to B is directed into the body from a coil placed on the surface of the body, the resultant magnet in the body will be turned out of alignment with B. However, the resultant magnet will not stand still. Like a spinning top which is deflected out of the earth's gravitational field, the resultant magnet will rotate, or precess, around the field B, Fig. 4b. The frequency of the rotation is a function of the magnetic moment of the precessing nuclei and the strength of the field M is called the Larmor frequency and is of the order of tens of MHz for fields of order 1 tesla (T). If the RF frequency is Larmor frequency, then the precessing nuclei will continue to absorb energy from the RF radiation and the resultant magnet in the body will continue to turn away from the field B. Indeed it may be turned right around to point in the opposite direction to field B.

If the residual magnet is turned to any angle it will precess at the same Larmor frequency. If now the RF radiation which is turning it is switched off, the precessing magnet will emit RF radiation of its own at the Larmor frequency. This RF radiation can be picked up by the same coil that was previously used to turn the magnet away from the field B, or another coil can be used. As time passes, thermal agitation and interaction of the proton with its surrounding neighbour atoms will cause the residual magnet to return to alignmet with the field B. As it does so the precession gets smaller and the emitted RF radiation falls steadily to zero, Fig. 4c.

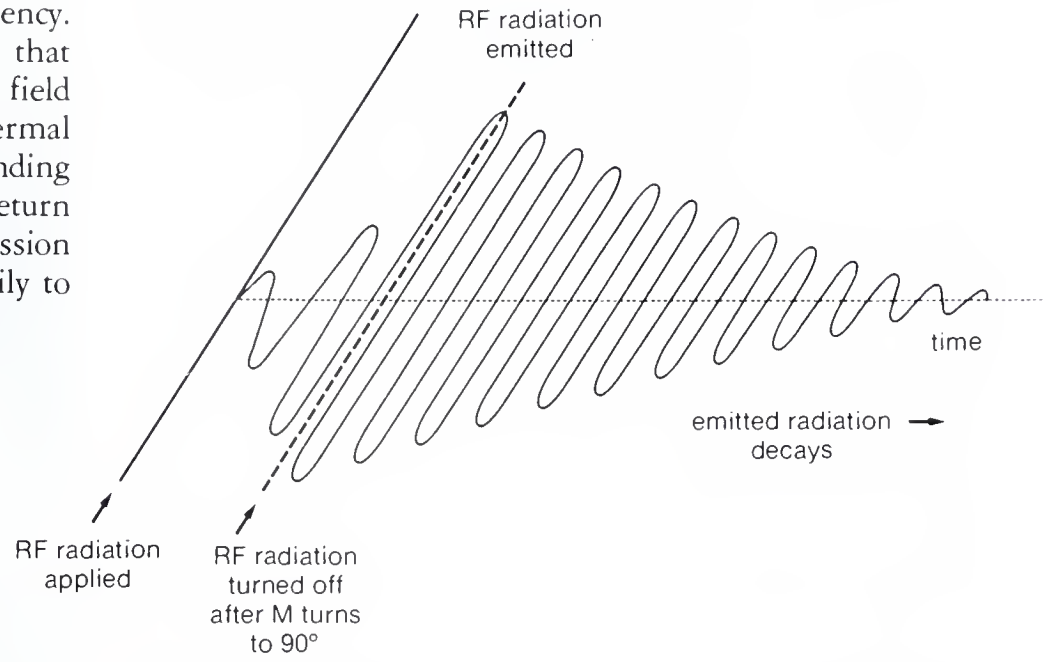

Figure 4c. Decreasing amplitude of RF radiation emitted by precessing M after applied RF field B^1 is removed.

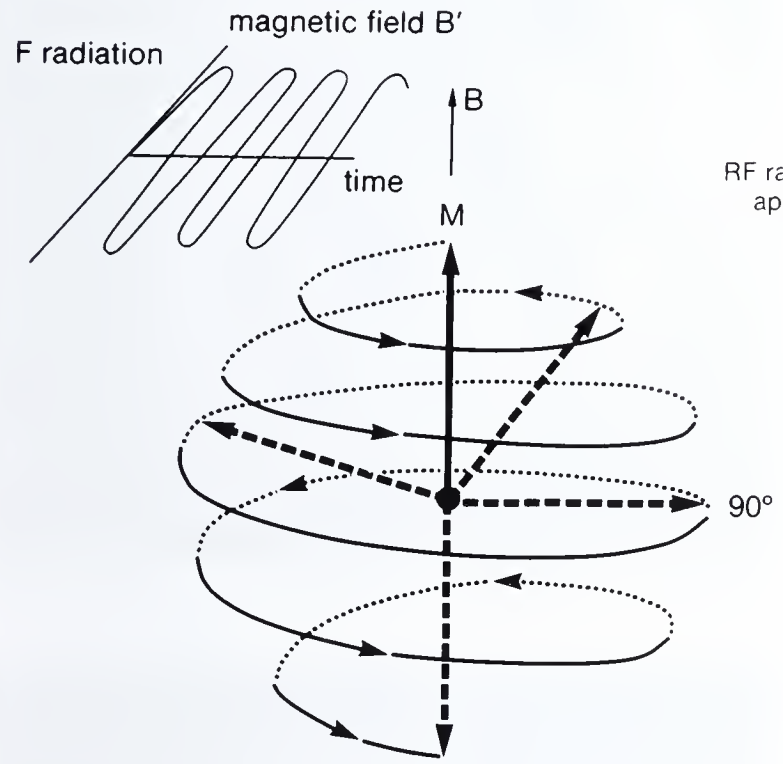

Figure 4b. Increasing amplitude of precession of M under the influence of the RF magnetic field B^1.

We can measure a number of things from this decaying RF field. Its initial strength is a measure of the number of protons in the body and its rate of decay, measured in terms of a time constant T_1, is an indication of the interaction of the protons with their surrounding atoms. The latter is particularly important because although water is abundant everywhere in the body, the interaction of protons with surrounding atoms varies substantially from one tissue to another. Measurement of T_1 will therefore enable us to differentiate between different tissues.

How then do we produce an image? We simply apply a magnetic field to the patient, then direct the RF radiation of appropriate frequency into the patient to start the precession. We switch off the RF radiation and put a gradient of magnetic field across the patient. Now, for each position in the patient the magnetic field, precession frequency and frequency of RF radiation emitted is different. To cut a long story short, by measuring the intensity of the emitted RF fields and their decay times at the different frequencies, and with other mathematical manipulations akin to those used in CT scanning reconstruction, we are able to reconstruct cross sectional images of the body based on proton content, on the time constant T_1, on another time constant called T_2 that measures interactions between the proton magnets, or a combination of these. Each image tells us something different about the properties of the tissues and may be able to separate to different degrees both normal and pathological tissues.

To say the least the images are startling, as can be seen in Fig. 1c and Fig. 5, and have now reached a quality that equals that in CT scanning, and for some purposes surpasses it. The advantages are: the fields used do not present any known risk to the patient and imaging can be repeated on a patient ad nauseum; sections of the body structure can be obtained at any angle through the patient without moving patient or machine by altering the direction of the magnetic field gradient; tissues hardly differentiated in other techniques are clearly visible in the appropriate images; bones give no signal since they contain little hydrogen, and therefore do not cuase image artefacts as they do in CT scanning; blood flow is easily detected because the precessing protons in blood are washed out of the section being imaged and therefore do not give a signal.[32]

This disadvantages of the technique are: to make scans in times of the order of seconds it is necessary to have a high magnetic field M, in the order of 1 T or more, so that the signal to noise ratio of the emitted RF fields is high — this requires super conducting magnets and a supply of liquid helium; as a result the cost of a machine is between one and two million dollars and running costs are high; the machine also needs a large space, say 12 × 20 metres, although the latest machines are being made smaller; buildings must be specially constructed free of iron or steel and other magnetic materials; and operators and patients must be screened for objects made of these materials to prevent the objects hurling into the magnet or changing the field M, although certain machines overvome these problems at some expense in cost or facility.

Thus, these machines will only slowly be introduced to clinical medicine and will tend to remain research tools for several years to come.[33] There are only a few in Canada at this time, only 1 in Toronto, at the Princess Margaret Hospital, and that already needs updating. More are planned for, including an MRI research research unit at the Toronto Western Hospital.

We have concentrated above on the imaging of hydrogen. However, it is also possible to study and image other atoms, such as P-31, Na-23, C-13, Ca-43, Fe-19.[34] These materials are present in the body in far smaller amounts than is hydrogen and their magnetic moments are smaller than for the proton. Measurement of these requires high magnetic fields (at least 1.5 T), much longer measurement times (many minutes) and much poorer image resolution. However this may all be worthwhile if one can study, for example, the metabolism of phosphorus in vivo. The binding of atoms to their nearest neighbours affects the Larmor frequency. Thus it is possible to differentiate between phosphorous in ATP, in ADP and in inorganic phosphate and changes between these chemicals can be followed in vivo. Similar effects can be seen in the binding of hydrogen. Research into the machines for doing this is well advanced and the prospects for imaging of metabolic processes in animals and humans are very exciting. It is likely to bring about a new explosion of knowledge about biochemical processes and physiological function in vivo, and as a consequence a wiser and more knowledgeable approach to health and disease. Any university medical centre that neglects to participate in this research, in spite of the costs, does so at its peril.

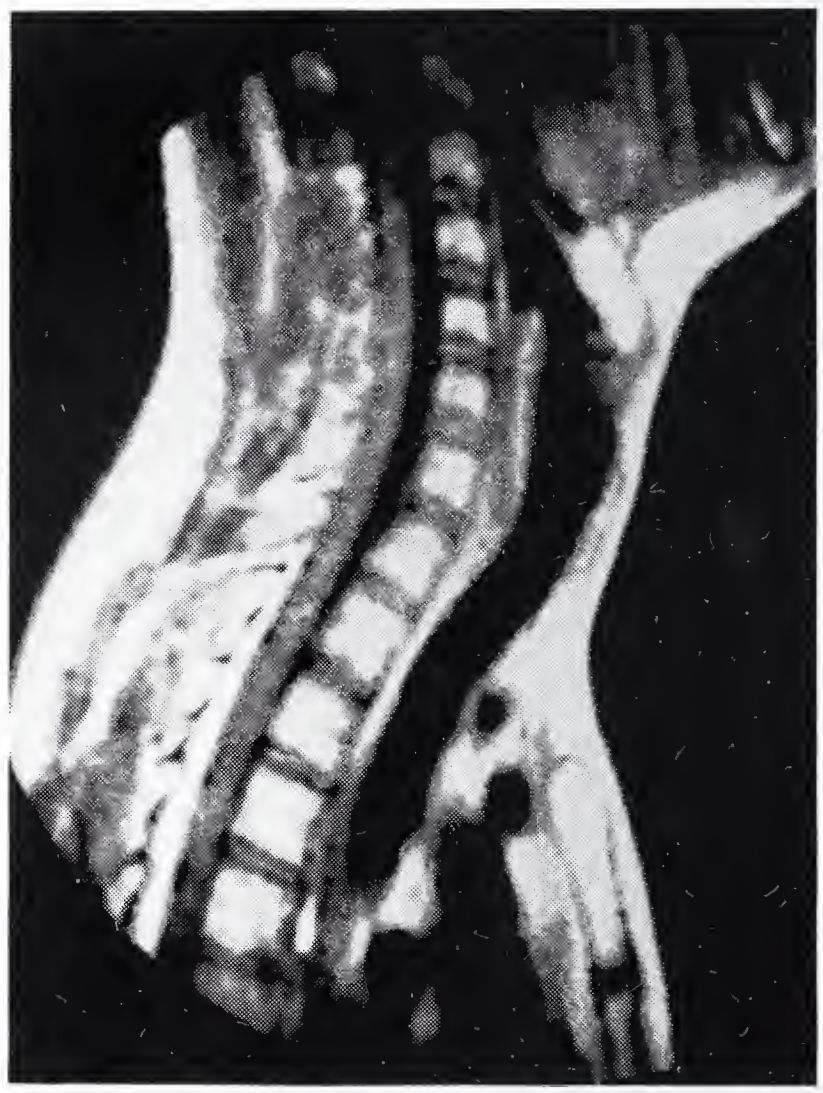

Figure 5b. A sagittal section of the upper chest and neck.

Figure 5 MRI images (courtesy General Electric Medical, U.S.A.)

Figure 5a. A sagittal section of the head.

Figure 5c. A coronal section of the trunk, showing liver, spleen, kidneys, renal arteries, aorta, vena cava, bladder, pelvic muscles and bones.

Conclusion:

There are many questions to be asked and answered about the place and efficacy of all this high technology in medical and health care. For the CT and ultrasound scanner, many of the answers are already in and these machines are common in our hospitals. But for PET, SPECT, MRI and many other new techniques much has still to be learned. One thing is clear however and that is the potential for medical, particularly clinical, research with many of these techniques.

Where does Toronto stand? Regrettably, like the Maple Leafs, it lags behind. Research into these new techniques is far ahead in the U.S.A. and even in other centres in Canada. McMaster has a PET scanner, London, (Ontario) has two MRI machines, Vancouver has research CT and MRI scanners, Montreal (at the Neurological Institute, Canada's leader medical imaging research) has several of these research tools.

Toronto has been a leader in the application of new medical imaging technology. In 1966 Dr. R. B. Holmes, then Chairman of Radiology and subsequently Dean of Medicine, introduced the first low exposure Isocon fluoroscopy unit to clinical use. In the early 1970's Dr. H. E. Aldridge, Director of the Toronto General Hospital Cardiovascular Investigation Unit, and I designed with Siemens and installed the first multidirectional cardiac x-ray machine, the Cardoskop-U, which had a major impact on the diagnosis and treatment of coronary artery disease[35] and a significant impact on general radiology. In those same years, Dr. R. B. Holmes called us on a Sunday morning from Chicago to come immediately and see the first CT scanner and within 18 months a machine was installed at the Toronto General, the second in Canada and one from the early production runs. In the late 1970's Dr. D. Hynes at St. Joseph's Health Centre led the world in reducing x-ray exposure to patients[36] and was early in introducing digital techniques. We have had the basic scientific skills and expertise at the Ontario Cancer Institute, Princess Margaret Hospital and at the R. B. Holmes Radiological Research Laboratories to back up the clinical application of these new technologies. But it takes a commitment, a sense of urgency, and the greatest cooperation amongst hospitals, university and government for us to remain a participant in this very competitive and exciting field. Let's go Toronto! It is not too late. I will guarantee you that we have not reached the end of the explosion.

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These references are a sample of the thousands of publications on this subject in the past few years. They are intended to introduce you to a topic at a fairly recent date, from whence you may trace back its development. Otherwise refer to the journals *Radiology, American Journal of Roentgenology* and *Investigative Radiology* or the many excellent books, growing daily in number, in the library of your friendly radiologist.

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In Vivo Neutron Activation Analysis for the Measurement of Bone Mineral

J. R. Mernagh, Ph. D., 8T6

The diagnosis and treatment of osteopenia requires a measurement of bone mineral of a sufficiently large section of the body to ensure that all areas of the skeleton undergoing bone resorption are covered. The measurement must also be sensitive enough to detect the osteopenia before fractures or vertebral collapse has taken place. In vivo neutron activation analysis provides such a measurement. This paper will describe the technique and present some patient results.

Introduction

Osteopenia, a generalized reduction in bone mass, is the diagnostic abnormality of osteoporosis. The resultant loss in bone strength results in fractures occurring either spontaneously or after minimal injury. These fractures most commonly occur in the spine (resulting in vertebral collapse) and the hips.

Since the reduction in bone mass is the only diagnostic abnormality of osteoporosis, a reliable measure of this reduction is required in the diagnosis and treatment of this disease. Conventional X-rays are not sensitive enough to determine bone loss until some 50% of the bone mineral has been lost, by which time fractures have occurred. Bone biopsies are difficult, painful and can easily miss that part of the skeleton undergoing bone resorption. A number of other procedures have been developed for the quantitation of bone mass, but none have proven to be entirely successful. For example, X-ray and gamma ray desitometry (ie. the use of a thin X-ray or gamma ray beam to measure the density across a section of peripheral bone) has been widely used because of its simplicity and low cost, but again, data from these procedures performed on bones of the peripheral skeleton, such as the hand or forearm, do not always accurately reflect the status of the skeleton as a whole or particularly that part of the skeleton most at risk from osteoporotic fractures: the vertebrae and proximal femurs.[1] Dual photometry and computed tomography are being developed to examine directly the vertebrae. These procedures may prove to be useful in the future but further work is needed to establish this.

Another method has been developed, to a large extent at the Toronto General Hospital. This is the technique of in vivo neutron activation analysis (IVNAA). It can be used to measure bone mineral in the total body or directed to the part of the skeleton at risk for osteoporosis. The procedure measures calcium and utilizes the fact that natural calcium has a small percentage of the stable isotope ^{48}Ca. This isotope, on exposure to thermal neutrons, is converted to radioactive ^{49}Ca. ^{49}Ca has a radioactive half life of 8.8 min., and in the process of decay emits a 3.1 MeV gamma ray which can be readily measured by a whole body counter. This paper will briefly describe the procedure and present a summary of some patient findings.

Method

At the Toronto General Hospital[2,3] we use plutonium-beryllium sources to produce the neutron beam. Twelve 5 Ci sources are used, each giving 10^7 neutrons/sec. The sources are arranged symmetrically above and below the body in such a way that an area 60 cm × 20 cm (length and width) of the trunk and upper thighs is exposed to an approximtely uniform flux which has an average value of 10^4 neutrons/cm^2/sec. This is shown in Fig 1. In this measurement, the 60 cm length is exposed for 20 min. The radiation dose received during this time is approximately 0.3 rem. After a 3 min interval for moving the patient from the exposure area to the counting area, the patient is "counted" in a whole body counter using four large NaI (Tl) detectors for 20 min.

The ^{49}Ca activity is directly proportional to the stable calcium and therefore to the bone mineral mass within this area. For diagnostic purposes we normalize the results for body size; the normalization procedure being developed from a population of normal volunteers aged less than 55 years. This normalized value is called the Calcium Bone Index (CaBI).[4]

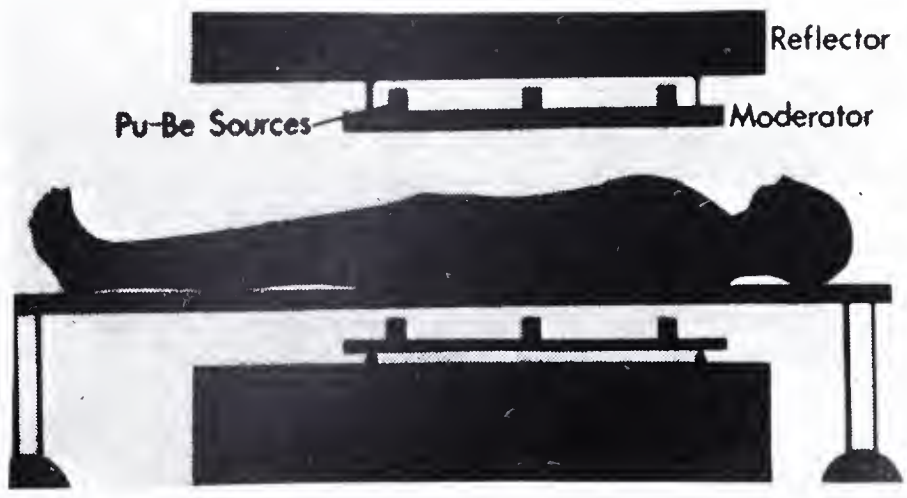

Fig. 1 Diagram illustrating the irradiation facility for the in vivo measurement of body calcuim.

**with grateful appreciation to Dr. J. E. Harrison, M.D. and Prof. K.G. McNeill, D. Phil.*

Results

The CaBI values for normal volunteers and for patients with osteoporotic fractures are shown in Fig. 2. For normal adults <55 years, the CaBI values spread ± 25% around the mean value of 1.0 with little difference between men and women. Volunteers over 55 years of age have, on average, lower CaBI values, consistent with the reported evidence of bone loss associated with aging. Patients with osteoporotic fractures, both those <55 and those >55, have a mean CaBI of 0.7 with a similar range of values (± 20%) (Fig. 2). In other words, osteoporotic fractures are associated with a 30% bone loss independent of age. The lower CaBI values in volunteers over 55 years of age reflect a real decrease in bone mass and a related decrease in bone strength.

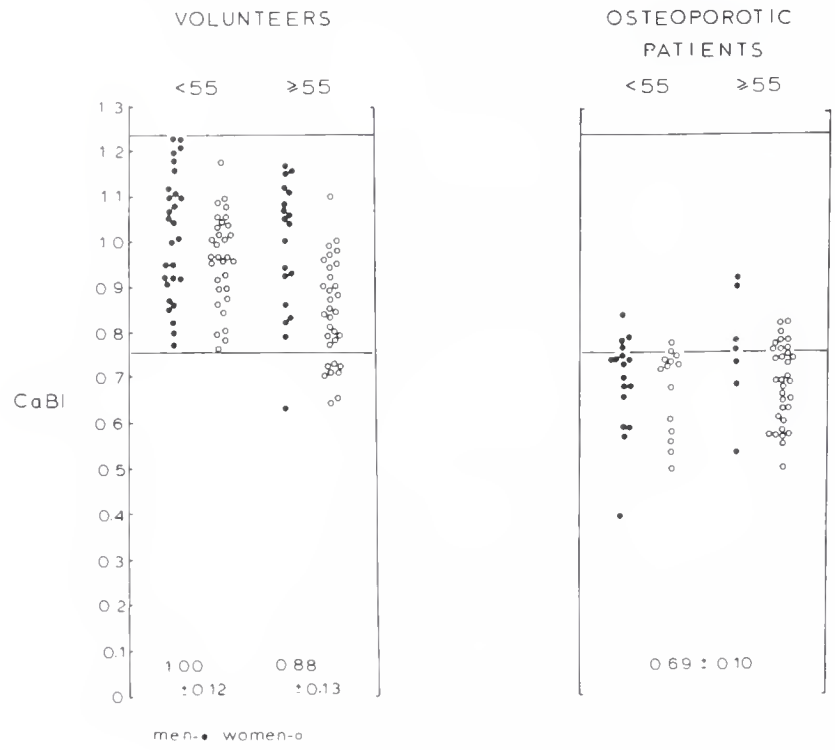

Fig. 2 CaBI values for volunteers and for patients with osteporotic fractures. Both groups are divided into those below and above 55 years of age.

Very importantly, the CaBI data show a good separation between osteoporotic patients and normal young adults with little overlap between the 2 groups. A CaBI value <0.75 is indicative of significant bone loss with increased risk of fractures while CaBI value > 0.9 excludes significant bone loss. The small overlap (CaBI values between 0.75 and 0.90) may be due in part to the inaccuracy of the measurement (± 5.5%) and to imperfect normalization,[5] but it is also possible that some volunteers (those with values < 0.9) have suboptimal bone mass and increased risk of fractures.

We have carried out CaBI measurements on patients with a number of diseases associated with osteoporosis. These are shown in Fig 3. To avoid ambiguity resulting from the effect of age on bone mass, all results reported in Fig. 3 were obtained on adults < 50 years of age.

Hyperthyroidism is a known cause of osteoporosis.[6] As a group, the mean CaBI value of 0.95 ± 0.02 (1 SE) was not significantly below normal, but a few patients had values below the normal range.

Diabetes is believed to cause osteoporosis. This group of 15 patients all had Type 1 diabetes for at least 20 years and all had

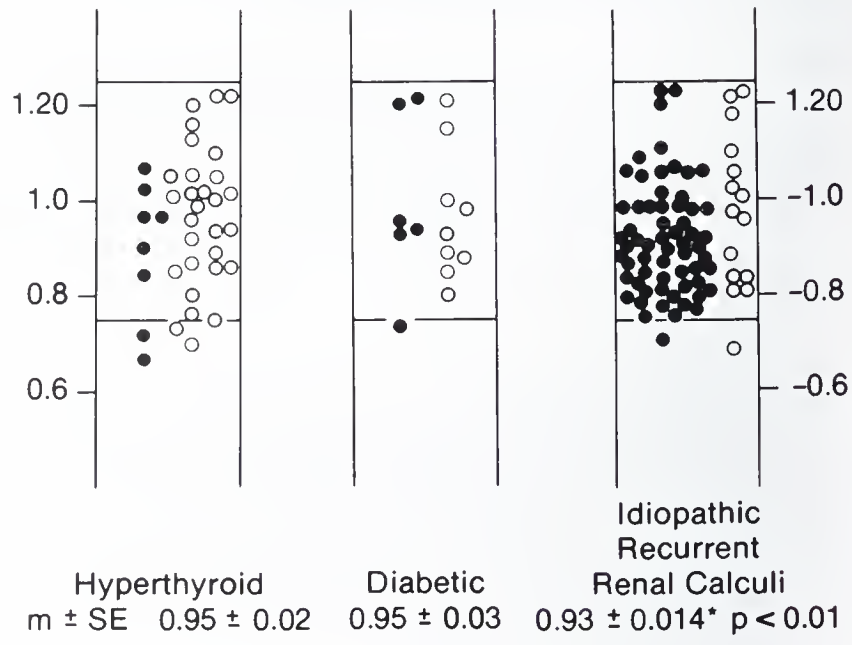

Fig. 3 CaBI values for patients with hyperthyroidism, long-standing juvenile onset diabetes and idiopathic recurrent renal calculi. All patients are <55 years of age. The lines indicate upper and lower limits for normal values.

the vascular complications of long-standing diabetes. Despite long-standing severe disease, as a group the mean CaBI value was not significantly below the normal mean value and only 1 subject had a CaBI value below the normal range.

In distinction to these two diseases which are believed to cause osteoporosis, idiopathic recurrent renal calculi has not been associated with bone loss, but our CaBI data show in this group a mean CaBI of 0.93 ± 0.014, which is significantly below the normal mean.

The CaBI measurements are used not only for the diagnosis of osteopenia but also to assess the effects of treatment. For example, Fig. 4 shows the changes in CaBI values observed over 2-3 years following successful treatment for hyperthyroidism. This group includes patients over 55 years old. On average the CaBI values increased 11% from 0.87 ± 0.15 to 0.98 ± 0.09. As might be expected the greatest increases were observed in those patients who, initially, had the lowest CaBI values.

The most common type of osteoporosis occurs in postmenopausal women. The cause is unknown although it is, at least in part, associated with the reduction in female sex hormone and for this reason is called post-menopausal osteoporosis. The effects on bone mass of various treatments for postmenopausal osteoporosis are shown in Fig. 5. The mean change in CaBI is shown at the end of each treatment year up to 4 years. Ca supplements are prescribed on the assumption that dietary intake or intestinal absorption of Ca is inadequate. With this treatment no significant improvement in bone mass was observed. Treatment with estrogen (female sex hormone) was associated with an increase of 6% by 2 years but no further improvement over the subsequent 2 years.

Patients treated adequately with NaF showed a progressive increase in bone mass up to 14% by 4 years. This marked improvement in bone mass, associated with NaF treatment,

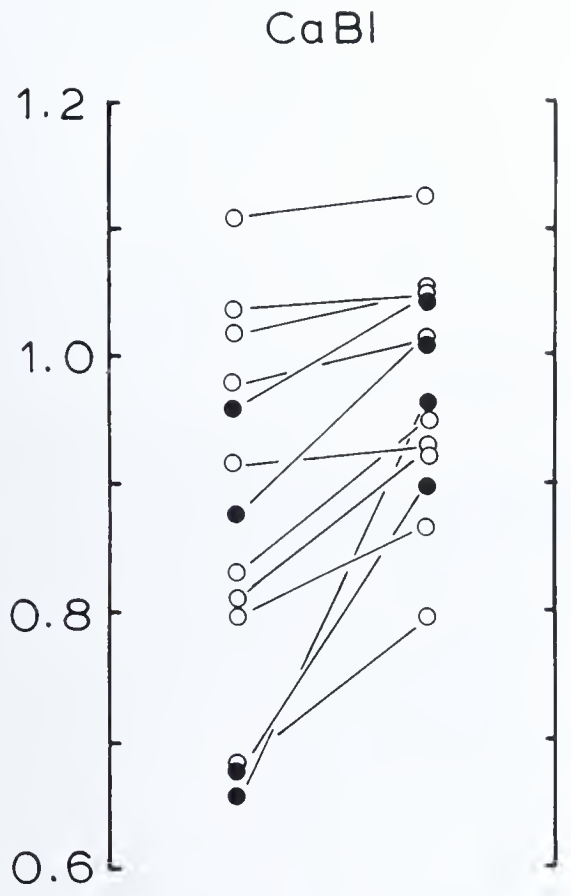

Fig. 4 CaBI values prior to and after 2-3 years of successful treatment for hyperthyroidism.

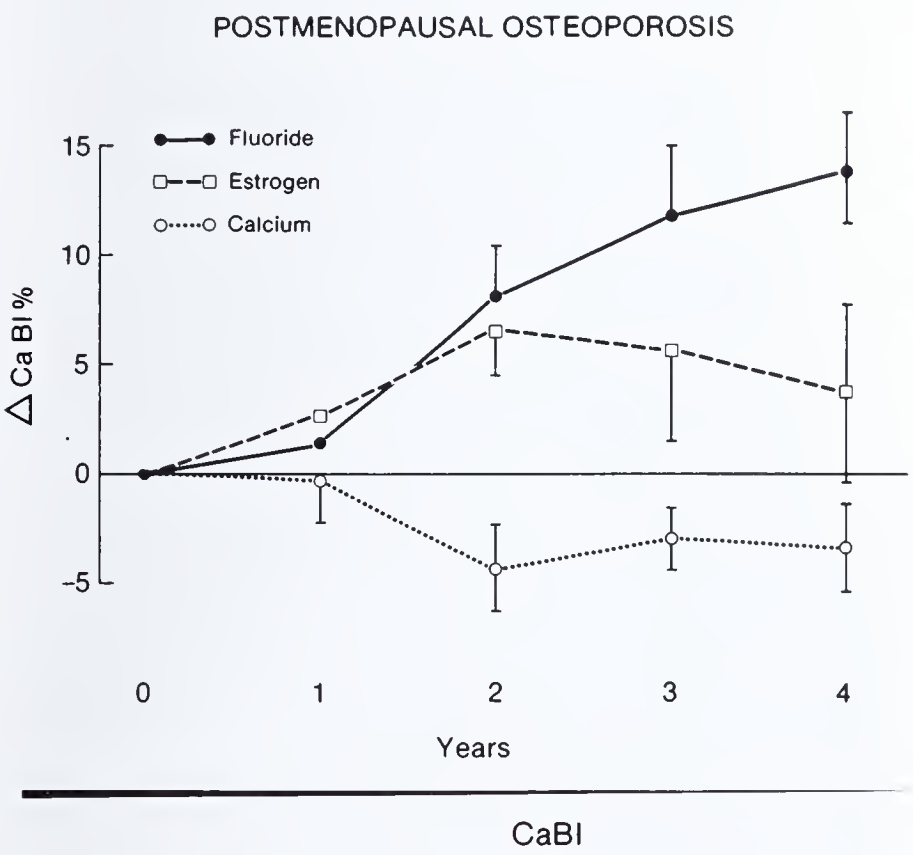

Fig. 5 Changes in CaBI values for patients with postmenopausal osteoporosis studied at the end of each year of treatment. Error bars are 1 SE. The changes in CaBI values are expressed as percent of estimated normal mean value (ΔCaBI × 100).

has not been reported with peripheral bone mass measurements (eg. gamma ray densitometry) although a qualitative improvement in bone density has been seen by spinal X-ray.[7]

Conclusion

Bone mass measurements by in vivo neutron activation analysis have proved of diagnostic value in the clinical investigation of osteoporosis. The IVNAA facility allows quantitation of a large bone sample which is truly representative of the part of the skeleton at risk for osteoporotic fractures.

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Mediastinal Mass in A Known Cirrhotic Male

E. P. Harris-Jones, M.B. Bch, F.R.C.P. (C)
G. L. Weisbrod, M.D., F.R.C.P. (C)

A 56-year-old male was first admitted to hospital in 1969 for investigation of hepatosplenomegaly. Examination at this time revealed hepatic and splenic enlargement, each two centimeters below the costal margin. A liver biopsy showed granulomatous disease, most probably due to sarcoid. There was no clinical evidence of liver failure. Splenomegaly was thought to be secondary to portal hypertension.

Apart from mild essential systemic hypertension, the patient was asymptomatic for the next 10 years. A routine chest roentgenogram taken at this time revealed a large mediastinal mass. (Fig. 1, 2) and the patient was readmitted for investigation of this mass.

Examination revealed a healthy looking male in no distress. The patient is a non-smoker and his chest examination revealed no abnormalities. There was still no evidence of liver failure but the spleen had increased in size to 4 cm below the costal margin. The hepatomegaly was unchanged. No history of hemoptysis or hematemesis could be obtained.

Special investigations, including CBC, serum glucose, serum electrolytes bilirubin, alkaline phosphatase and SGOT, were normal. The PT and PTT were minimally prolonged and the serum gamma globulin was slightly increased.

Radiographic investigations were taken (Figs. 1-7)

WHAT IS YOUR DIAGNOSIS?

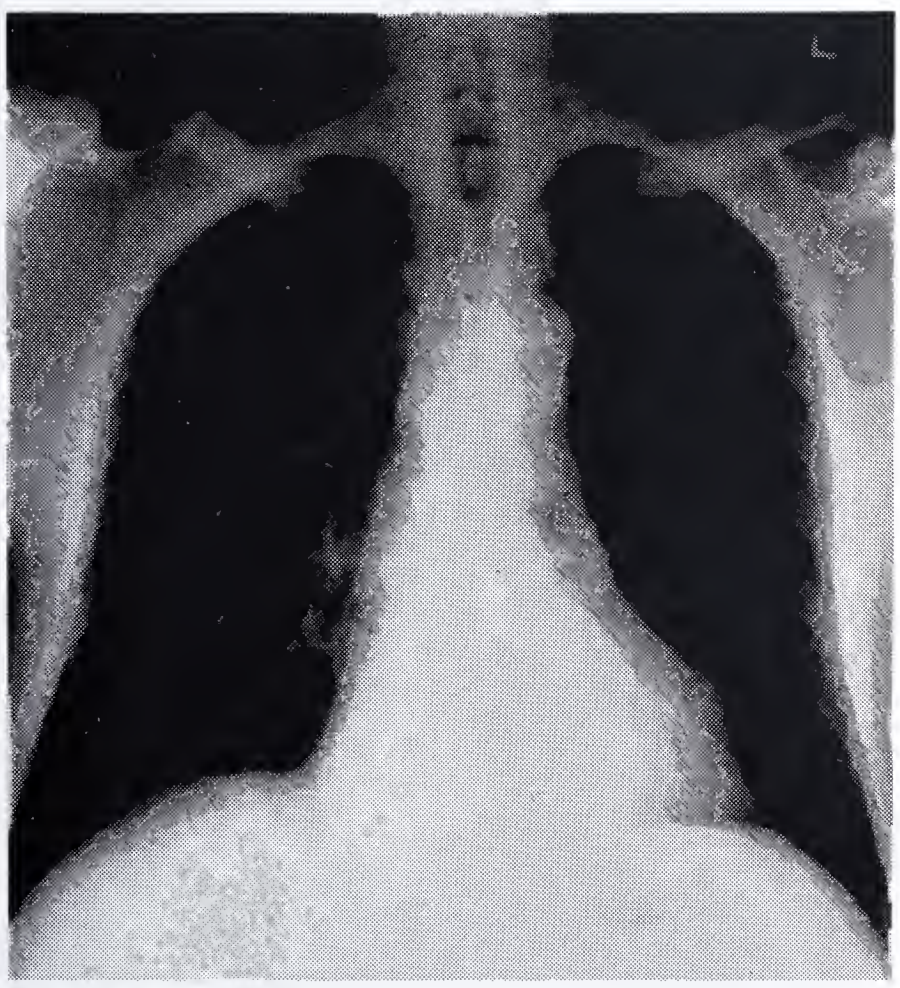


Fig 1 Chest roentgenogram, AP view

Fig 2 Chest roentgenogram, lateral view

Fig 3 Chest tomogram

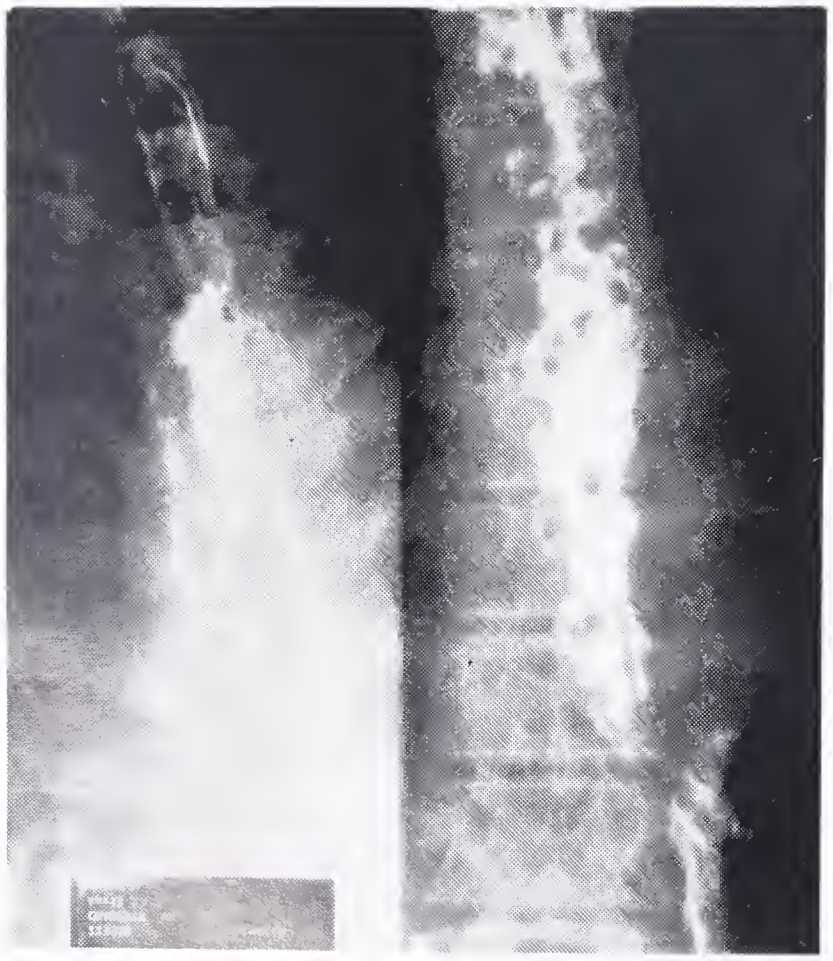
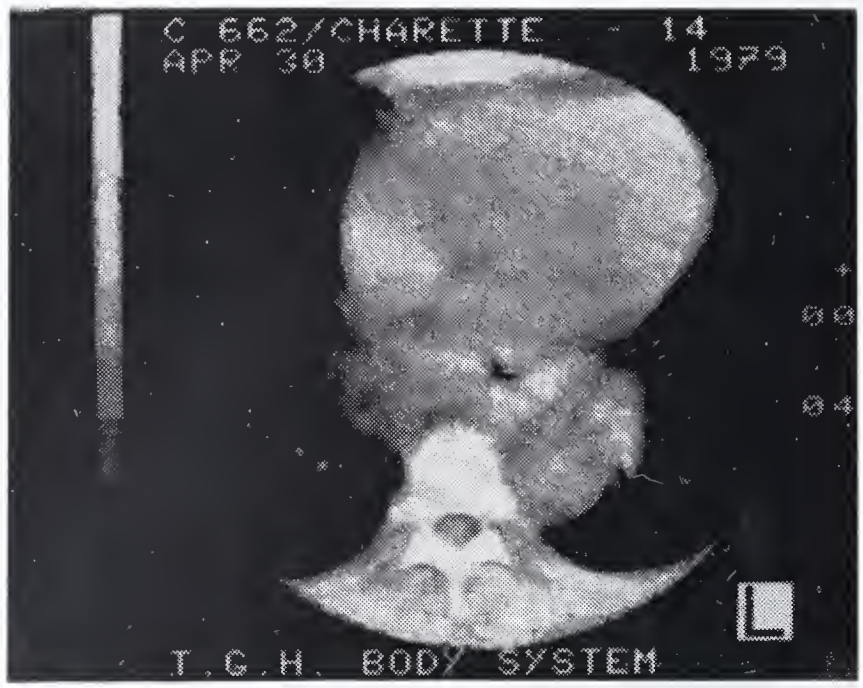


Fig 4 Barium Swallow



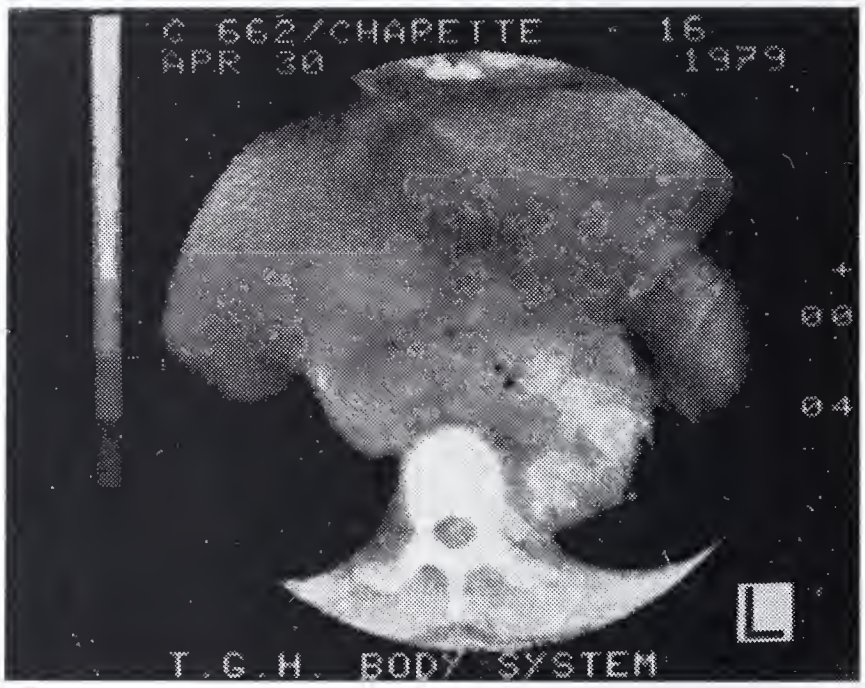


Fig 5 CT Scan

Fig 6 Angiography

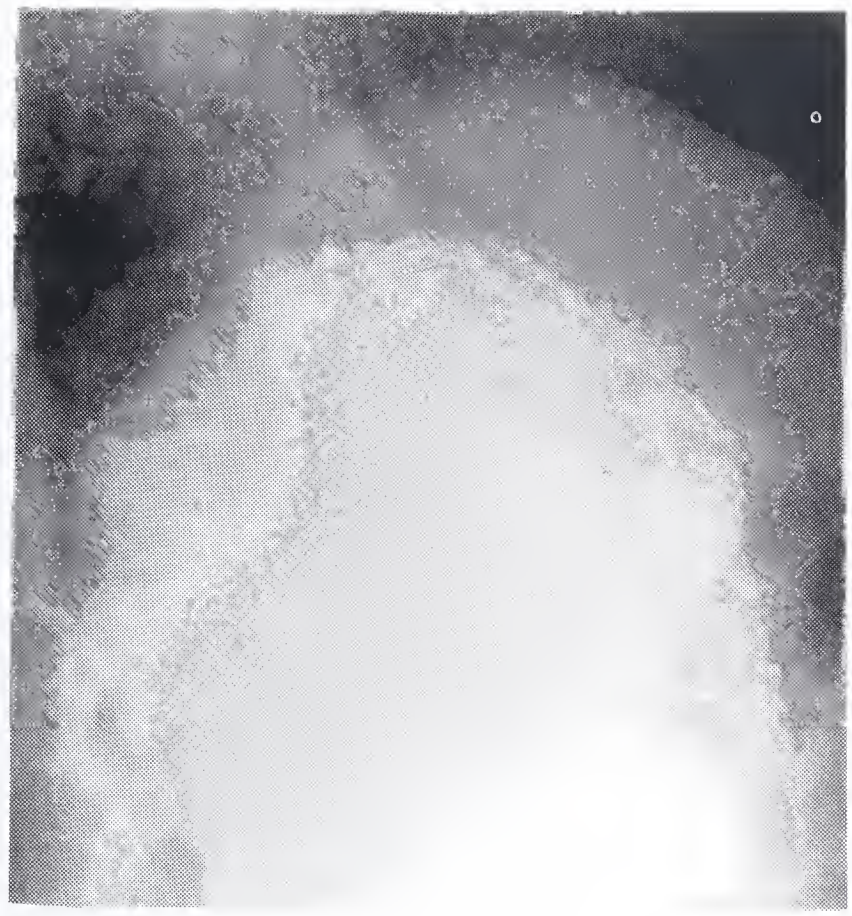


Fig 7 Angiography

In 20 years there could be no new drugs to imitate

A realistic "full disclosure" of the effects of generic prescribing should include — as a major potential side effect — the reduction, if not outright elimination of new drug research in America.

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Proton Beam Therapy for Arteriovenous Malformation of the Brain

Douglas Kondziolka 8T5

Arteriovenous malformations of the brain may be managed by a variety of surgical or non-surgical modalities. For lesions deemed inoperable because of size, location or surgical risk, Proton Beam Therapy (PBT) via Cyclotron presents a therapeutic alternative. The technique is used for patients presenting with hemorrage, seizures, headache or progressive neurological deficits. To date, PBT is performed at the Harvard Medical School with 439 patient profiles reported. These results will be presented in this paper.

Although other non-surgical interventions are available for the management of these lesions, none are as non-invasive as PBT. For the neurosurgeon, Proton Beam Therapy may now offer a viable management alternative to what was previously considered unmanageable with surgery.

Arteriovenous malformations (AVM) of the brain are congenital, slow-growing anomalies wherein blood flow from the arterial circulation empties into the venous circulation without passing through a capillary network. A formed tangle of these anomalous vessels can lead to mass effect or selective ischemia via a steal phenomenon. High pressure blood flow emptying into a lower pressure system predisposes to hemorrhage. AVM's may present in a variety of fashions, the most common of which are subarachnoid hemorrhage, headache, seizures or neurological deficit. Presentation may also occur at any age.[1,2]

Choice of therapy is dependent upon lesion location, size and patient surgical risk. For example, AVM's located in the speech centres or in the brainstem are clearly not good surgical candidates.[2] As well, very large lesions may not be surgically amenable. Cardiopulmonary or other systemic disease may also prevent surgery.

These contraindications to operative removal are by no means absolute. It is a nerurosurgeon's personal experience and judgement that helps him determine how large a lesion must be before being labelled inoperable. For example, although most would agree that brainstem AVM's are poor surgical candidates, surgical attempts in the speech centres, where lesions may be more amenable to treatment, have been made. Kunc reports five 'cures' and one improvement in six pre-operatively dysphasic patients, with no worsenings.[3]

For smaller lesions in surgically accessible regions which do not unnecessarily endanger normal brain tissue, microsurgical evacuation of the AVM may be performed.

Embolization of the lesion with silastic spheres via arterial catheterization is also possible.[4] In this method, the relative size of arteries to veins is considered in order to prevent sphere occlusion of normal cortical branch vessels. However, it is impossible to avoid embolizing a few normal vessels ("iatrogenic stroke"). Balloon catheterization with injection of isobutyl cyanocrylate (IBCA) into the entrance of the AVM is more risky but ideally spares normal vessels.[5] Using these techniques, 50% of large, seemingly inoperable AVM's, can be made amenable to surgery. However, even with this combined procedure, the neurological complication note is still high at 20%.[6]

Proton Beam Therapy

When lesions are either considered inoperable, or a patient chooses to avoid craniotomy, they may be referred to Massachusetts General Hospital for PBT. Referrals come from all over the world. Approximately a one year waiting list is presently in effect. On admission, patients receive a full assessment including neurological and neuro-ophthalmological and consultation, CT scanning and cerebral angiography. From these studies, the size and volume of the lesion is calculated.

Proton Beam Therapy utilizes the Bragg peak of the proton beam to irradiate a selected lesion site determined by stereotactic localization. A beam diameter between 7 and 50mm is used in coordination with a specified radiotherapeutic dosage. This is referred to as the isoeffective dose. It is known that the threshold (one percentile level) for cerebral necrosis varies from 1050 rad for 50mm beams to 5000 rad for 7mm beams.[1] It is also appreciated that viable brain may exist within the AVM mass. To avoid brain necrosis, a dose below the first percentile of isoeffectivity is used. (Figure 1)

A stereotactic frame is applied to the patient's head under local anaesthesia. Radiation is then administered. The entire procedure takes approximately 1.5 — 2.0 hours. Patients are discharged from hospital the day after treatment.

The method by which PBT induces its effect on the anomalous cerebral vasculature is still speculative, but highly

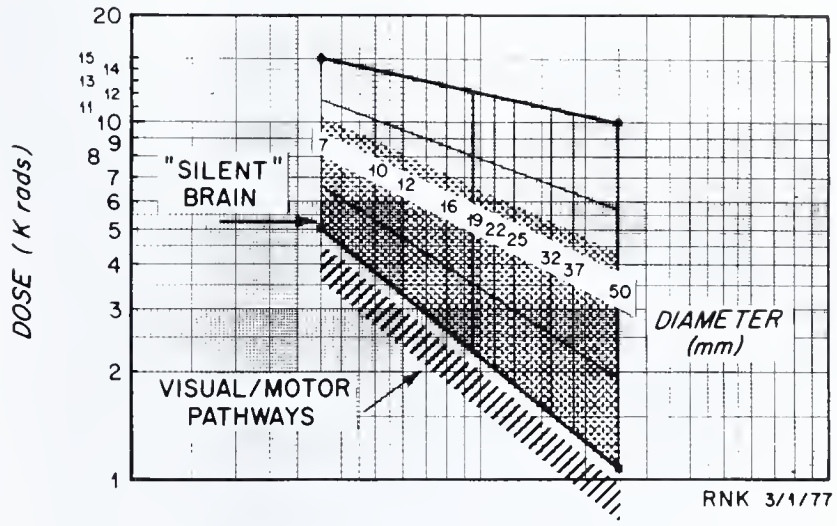

Figure 1 Determination of AVM dose. The bottom line of the four sided figure represents the one percentile isoeffective dose for cerebral necrosis in normal brain. For a small beam (7mm), the one percentile dose is 5000 rads. To provide a margin of safety, a dose below the one percentile level is used.[2]

agreed upon. It is thought that an ionization occurs whenever a proton enters the nucleus of endothelial cells within the AVM. This ionization creates a break in the DNA nucleotide sequence, which may have no immediate significance. It may be quite some time before the replicative or metabolic functions mastered by that segment of DNA is altered. In fact, this alteration alone may have no detrimental cellular effect. The achieve response may be the result of many ionizations on the single cellular level.[2]

It is also interesting to note that there is much inter-individual variability in achieving cerebral necrosis with irradiation. In patients with previously damaged brain tissue (stroke, craniotomy), there appears to be a lower radiation tolerance.

Proton Beam Therapy has proved to be of use not only for AVM's, but also for pituitary adenomas. In fact, 987 cases of pituitary treatment have been reported. These have included 537 cases of acromegaly[7], 156 cases of Cushings Disease[8] and 31 cases of Nelsons Syndrome[8].

Pathology

Presently three specimens have been obtained from PBT patients for analysis. Two of these were surgical removals (one 2.5 years post-PBT; the other 32 months post-PBT). The other specimen was from a post-craniotomy death 3.3 years post-PBT.

On microscopical examination, the lumens of all vessels were either totally occluded or greatly reduced. Vessel walls were thickened, and the normal layers were not distinguishable in many cases, being replaced by collagen. In areas adjacent to the AVM, meningeal thickening was noted close to the pia-arachnoid junction. Furthermore, gliosis was observed in brain tissue between thickened vessels. However, no mitoses or any sign of neoplasia was observed.[2]

Results

PBT has been performed on 552 patients, with 303 patients having follow-up greater than two years. To date, 444 procedures have been reported on 439 patients. Of these, 260 patients are presently two or more years post-PBT and follow-up is available on 244 of them (94%). The first procedure was performed in 1965. An "incubation period" of 1.5 — 2 years is usually observed before any demonstrable effect is seen clinically or angiographically. This relates to the time-delayed DNA ionization theory explained above.

Hemorrhage

A total of 206 patients (47%) have been treated who presented with hemorrhage as a first symptom. 203 patients are still living, of which two have increased deficits. The three deaths that occurred did so during the incubation period (2, 11 and 12 months). Twenty-three non-lethal hemorrhages (13 within the incubation period) have occurred and these have resulted in the two patients with increased neurological deficits.

Within the same patient group, the hemorrhage rate during the incubation period was 7.25% per year. After 2 years post-PBT this rate dropped significantly (p 0.005) to 2.4% per year.[2]

Seizures

Patients presenting with a seizure disorder make up 32% of those treated. There is much clinical variability between patients with the result that pre and post PBT comparison is difficult. (Figure 2)

Out of 118 treated patients, one-half report their disorder improved; one-fifth report no change and 2 patients report worsening. These worsenings consist of progressive weakness 3.3 and 3.9 years post-PBT, considered to be due to ionization injury. Both patients died after undergoing craniotomy for their lesions. Two patients died of hemorrhage (9 and 15 months post-PBT) within the incubation period. There was also one death from hemorrhage 4.6 years post-PBT. This is the first patient to die from an AVM more than 18 months after undergoing PBT.[2]

It is important to note that patients with seizures and an AVM who are well controlled with anticonvulsant medication, may not be candidates for PBT.

Headache

Patients with headache as their major symptom constitute 11% of the total. Headaches were described as disabling. Also experience has shown that other symptoms follow in 80% of patients presenting with headache.

Two-thirds of patients report mild to moderate headache improvement. One-third report no change. One patient reported worsening. Three patients sustained hemorrhage and died (2 x 1 mo. post-PBT, the other 18 mo. post-treatment). There have been no deaths after 2 years, but several other non-lethal hemorrhages have occurred leading to neurological deficits.[2] Interestingly enough, one patient sought craniotomy one year post-PBT for persisting

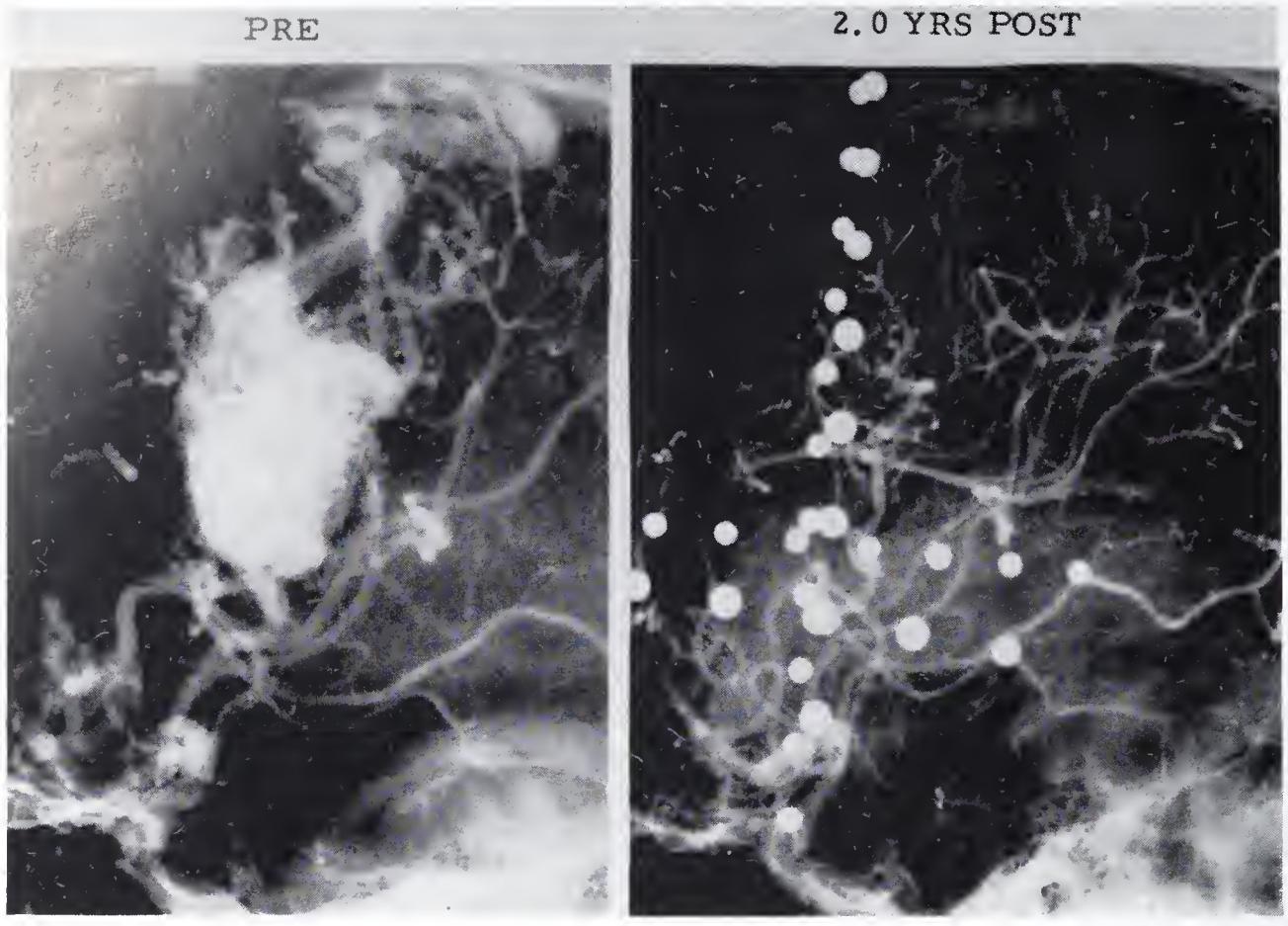

Figure 2 Pre and Post PBT cerebral angiograms. The left shows a large AVM fed by the left Middle cerebral artery and drained by a distended vein. The right angiogram is two years post-PBT in the same patient showing almost total reduction in the AVM.

headache. Although a complete AVM excision was performed, the headache continued to persist.

Progressive Neurological Deficit

This group also comprises 11% of those treated with PBT. Presentations include hemiparesis, hemianopsia, ataxia and cranial nerve palsies. Treatment goal is arrest of deficit progression.

Over one third report deficit improvement, with approximately two thirds reporting either arrest in their worsening, or improvement. Within the two year incubation period, seven cases of deficit progression occurred but these all arrested. One patient has continued to worsen beyond these two years. Non-lethal hemorrhages have occurred at 1.5, 10 and 39 months post-PBT. There have been no deaths in this patient population.

Complications

Most complications were observed in the first 75 patients as that time, radiotherapeutic dosages were not accurately known and have since been modified as experience has grown.

Four of the first twelve patients received beams of large diameter and sustained injury to corticospinal pathways. As a result, the dosage was lowered to a level below the first percentile isoeffective dose.

In the past 370 procedures (patients 74 — 444), only one complication attributed to PBT has occurred. This involved a patient with a persistent left hemiparesis who developed significantly worse spasticity seven months after PBT.

An important observation has been made post-PBT in patients treated for seizures. In ten epileptic patients, seizures developed within 24 hours after treatment. It seems that PBT itself may transiently lower the seizure threshold. In response to this, anticonvulsant therapy is increased for a few days after PBT with good result.

In AVM's located in central diencephalic areas, transient increases in body temperature have been observed, with no detrimental effect.[2]

There have been no procedure related complications from the stereotactic frame or anaesthetic. There have been no hemorrhages related to the treatment and no infections.

Of the 244 patients followed two years or more, 57% have had follow up angiograms. Results range from total AVM obliteration to no demonstrable changes.

In the first group of 75 patients, 66 had follow up angiography. 20% showed total obliteration, 56% had greater than 50% AVM reduction and 13% showed no change in AVM size. There has been no angiographic worsening after PBT. In the larger group of 244 patients, similar results are seen in that 22% of patients achieved total AVM obliteration.

Case Presentation

A 22 year old male presented to the hospital with the acute onset of severe headache, mild photophobia and two episodes of vomiting. He had been previously well with only occasional mild headache. He was not on any medications. There was no history of trauma, recent infections or previous similar episodes. He had no paraesthesiae or weakness, and no change in gait, bowel or bladder function. He had never had a seizure.

On examination he looked distressed with headache. There was moderate meningismus . He was slightly drowsy but oriented in three spheres. Testing of recent memory was slightly impaired but the rest of his mental status was normal. All cranial nerves were normal, as was testing of his limbs. The rest of his systems examination was normal. A diagnosis of subarachnoid hemorrhage, grade I, was provisionally made.

He underwent angiography which disclosed a large right posterior cerebral AVM. This was considered inoperable due to size and loction. He was referred for Proton Beam Therapy. Two months later he received PBT. Angiographic follow up at 2.1 years disclosed 96-99% reduction in AVM size. At 7.2 years, his lesion was felt to be totally obliterated. (Figure 3) He had no further hemorrhages and has continued to do well.

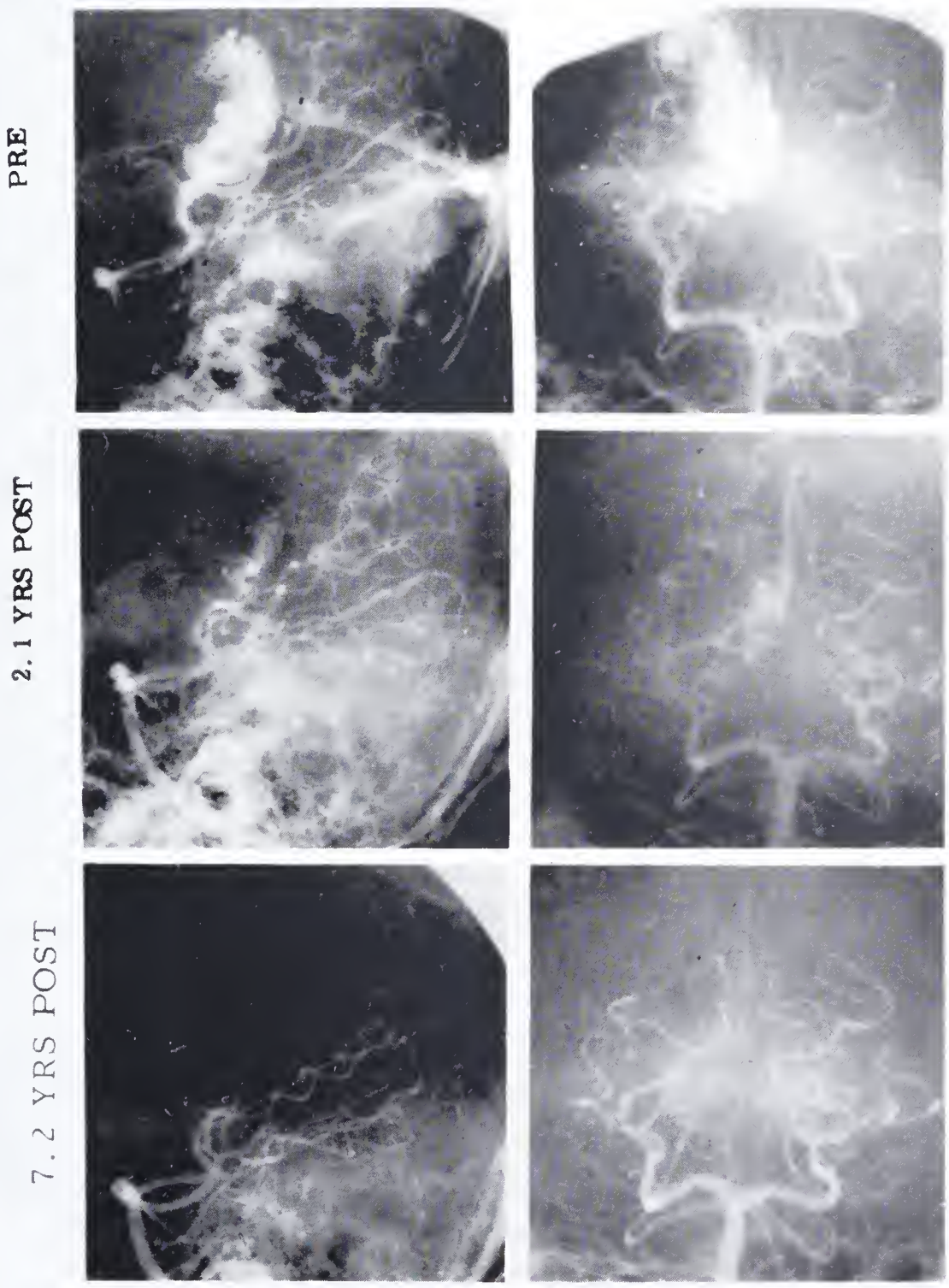

Figure 3 Pre and Post PBT cerebral angiograms. The left angiograms are lateral views and the right are P-A. The Pre angiogram depicts a large posterior cerebral artery AVM. 2.1 years after PBT, there is 96-99% reduction in AVM size. 7.2 years post-PBT, the AVM is completely obliterated.

Summary

It appears that a key factor in determining the current use of Proton Beam Therapy is whether an AVM receives the "inoperable label" or not. Clearly, this label is not a well defined entity. For patients presenting acutely with obtundation and coma, craniotomy may be indicated despite the size of the lesion. As noted previously, the "incubation period" of approximately 18 months denies PBT a role in acute management.

However, the two modalities may prove to work well together. PBT performed on inoperable lesions may sufficiently reduce AVM size enabling evacuation. This has been performed on two patients to date.[2]

An important question frequently asked in any discussion of AVM management with PBT is, "If PBT is so good, why is there only one treatment center? Surely more people would be utilizing PBT". There are a number of responses to this question. First, although PBT has been performed for many years, results have not been published until two years ago. The lengthy time period required to acquire a large data base and follow up population, as well as continued technique refinement, have necessitated late publication. However, publication throughout the refinement process would have allowed closer scrutiny and input by the neurosurgical community.

Second, the technique itself requires a large physical plant in order to accelerate protons. To allow one procedure, this kind of plant would not be cost-effective for many neurosurgical centres when the option to refer to Massachusetts is available.

The future of selective cerebral embolization seems almost as bright as that of PBT. Until AVM management becomes unilateral, various centres will choose to perform and improve their own therapies. It would not be improbable that another centre for PBT would arise as need dictates. However, it may well be that patients who ten years ago would be referred for PBT, are now referred for embolization. This may be so especially in lieu of a one year PBT waiting list.

Despite the fact that the procedure is presently limited to one hospital, one certainly cannot disregard the impact of PBT on AVM management. Subarachnoid hemorrhage, seizures and neurological deficits need not continue in patients with seemingly inoperable lesions. Although a two year waiting period must be observed before seeing real benefit, the benefits *are* being realized. With realistic goals of seizure control, deficit arrest and hemorrhage prevention, PBT can be seen, not as a last-ditch alternative, but as a definitive positive therapeutic intervention.

Acknowledgements

The author would like to thank Dr. Raymond Kjellberg and staff at the Massachusetts General Hospital, who stimulated and facilitated this report. A very special thanks also goes out to Dr. Karl W. Swann and Dr. Joseph R. Madsen, who besides offering experience and teaching, allowed me to participate freely on their team at MGH.

Thanks also to Dr. J.F.R. Fleming of the Toronto Western Hospital, without whom this experience and report could not have been.

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The Use of Allograft Replacement for Bone Stock Loss in Total Hip Revision Surgery

Paul H. Marks 8T6

It is now recognized that joint revision surgery in the presence of major bone stock loss cannot be successfully carried out with the use of implants alone. Autograft or allograft bone may be used with implants depending on the type and size of the defect at the time of revision. This prospective study looks at the results of hip revision surgery by reviewing the patients with an organized surgical protocal. The use of bioimplants in hip revision surgery will be illustrated by case presentations.

Background: Total Hip Displacement

The history of total hip replacement has advanced since the year 1890 when the components were of ivory and a grouting agent used for fixation. There has been an era of design in stainless steel. This has progressed to a more successful period with the use of cobalt-chrome and the popular high density polyethylene cup.

In 1962, Professor Sir John Charnley pioneered the Total hip replacement with the materials which now are commonly used. This marked the beginning of major joint replacement. At present, thousands of such operations are performed annually.

Over the past ten years it has become apparent that the lifespan of conventional cemented total hip arthroplasties is limited. Most commonly the mode of failure is aseptic loosening. However, this frequently combined with a loss of bone stock which may be due in part to the loosening itself, to 'stress shielding' or to the "massive lysis" described by Harris in 1982.[4] Bone grafting procedures used in conjunction with total hip revision surgery are now well accepted and commonplace.[2,3,6] However, in cases of multiply revised arthroplasties or in cases of massive bone loss it is not always convenient or even possible to use autograft bone. For this reason, the use of allograft bone has been utilized to reconstitute bone stock in cases where it was necessary.

Initially, allograft replacement was used in patients with protrusio acetabuli. In more recent cases, acetabular shelves, acetabular columns and proximal femurs have been fabricated using allograft bone.

Technique

By using a systematic approach the bone stock deficiency is defined, infection is ruled out, the type of graft to be used is determined, and selection of the appropriate hardware is made. The deficiency is defined radiologically. This involves the use of routine x-rays, judet views, and when indicated, a CT scan. Following this, investigations are performed to rule out sepsis. The type of graft to be used is then determined. (See Table 1). For protrusio, either allograft or autograft can be used. The lateral acetabular deficiency secondary to dysplasia can be treated with femoral head autograft or allograft. All other forms of acetabular deficiences and all femoral deficiencies have been treated with allograft.

Table I
Bone Grafts in Hip Replacement Surgery

Deficit	Graft	
A Proximal Femur		
i calar	allograft	revision
ii proximal femur	allograft	
Pelvis		
i protrusio	autograft - primary allograft - revision	
ii shelf	autograft - primary allograft - revision	
iii acetabular reconstruction		
A) column (anterior or posterior)	allograft	revision
B) composite	allograft	

In addition to the use of allograft bone it is preferable to have a prosthetic device that goes from normal bone to normal bone. This combination of allograft with prosthetic device is called bioimplant. Finally, the interface of host to allograft bone is augmented with autogenous bone graft. In this review, three Bosch-Schneider rings, fourteen Mueller rings and five meshes have been used in twenty-five acetabular reconstructions. More recently a new fixation device has been developed to meet the needs of difficult reconstructions. This bio-implant has a modular acetabular ring design. The attachment of various processes to the circular ring permits the surgeon to build an acetabular ring according to the need of the patient. (See Figure 1). On the femoral side, long stem press-fit femoral components have been used in most cases.

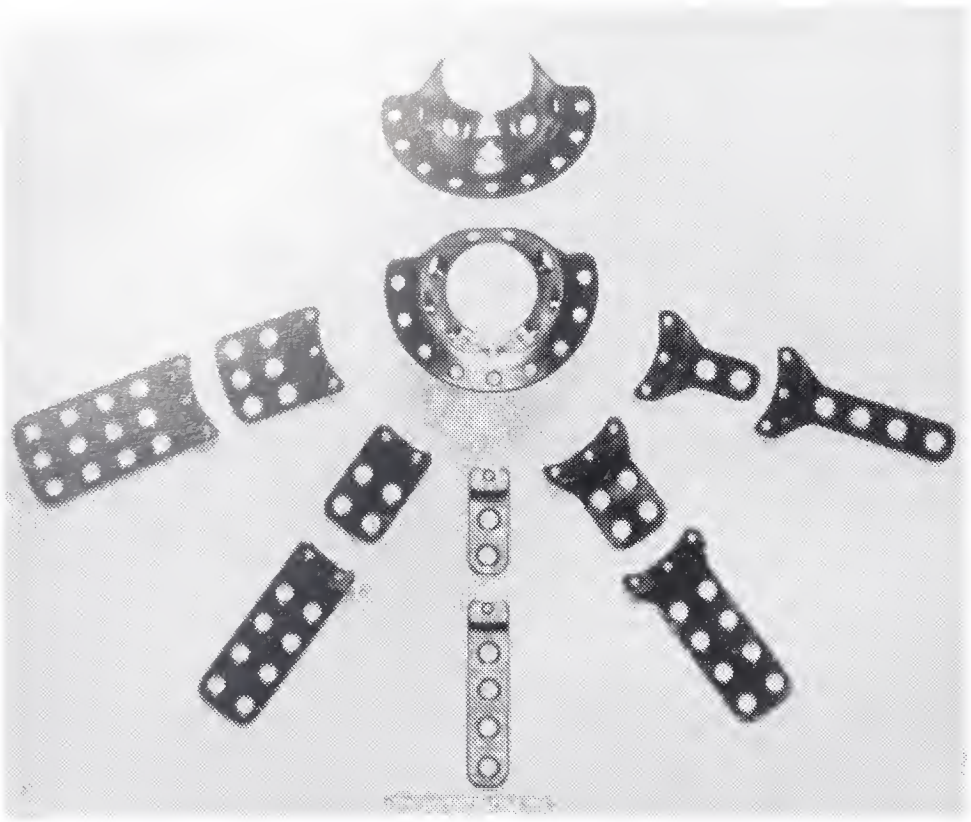

Fig. 1

All allografts used in hip revision surgery were frozen. They were initially acquired either from prior hip surgery (ie. femoral heads) or in cases of massive allografts through the Metropolitan Toronto Organ Retreival Program. Any donor must meet the criteria outlined by the American Association of Tissue Banks.[1] The donor tissue is provided in the operating room under sterile conditions and is deep frozen at -70 degrees centigrade.

Materials And Method:

As of September 1, 1984, 52 allografts have been performed on 44 patients for revision hip arthroplasties. Twenty-seven patients having undergone 30 revision procedures using allograft bone and having a minimum 6 months follow-up were reviewed. There were a total of 38 allografts performed in this group. Seven patients were male and 20 were female. Average age was 60 years with a range of 21 to 84 years. The average follow up was 17 months with a range of 6 months to 72 months. The average number of previous operations on the hips was 2.5. The hips were evaluated pre and post operatively using a protocol which awarded a maximum of 100 points. This protocol was based on the Harris System. Forty-four points are awarded for pain relief, 33 for function, 13 points for activities, 5 points for deformity and 5 points for range of motion. (See Table II). The hips and grafts were also evaluated radiologically for loosening, graft resorption, graft consolidation and union.

The acetabular deficiencies were classified anatomically, with 16 protrusio, 4 shelves, 1 anterior column and 1 posterior column and 2 composite deficiencies in this series. A composite deficiency is defined as a large circular defect that extends in all directions and involves just a small part of both columns. Femoral deficiencies are classified as focal on either the lateral or medial aspects or as circumferential. This latter defect is further classified as calcar or proximal femur.

Table II

HIP RATING

Pain

44 = none
40 = slight
30 = mild
30 = mod., occasional
20 = moderate
10 = marked
0 = disabled

Function: Limp
11 = none
8 = slight
5 = moderate
0 = severe

Support:
11 = none
7 = cane, long walks
5 = cane
3 = 1 crutch
2 = 2 canes
0 = 2 crutches

Distance Walked:
11 = unlimited
8 = 6 blocks
5 = 3 blocks
2 = indoors
0 = bed & chair

Activities: Stairs
4 = normally
2 = with railing
1 = any manner
0 = unable

Shoes & Socks:
4 = with ease
2 = with difficulty
0 = unable

Sitting
4 = any chair, 1 hour
2 = high chair
0 = unable to sit comfortably

Public Transportation:
1 = able to use
0 = unable to use

Deformity: Fixed Adduction
1 = <10 degrees
0 = >10 degrees

Fixed internal rotation:
1 = <10 degrees
0 = >10 degrees

Fixed external rotation:
1 = <10 degrees
0 = >10 degrees

Flexion Contracture:
1 = <15 degrees
0 = >15 degrees

Leg length discrepancy:
1 = <3 cm
0 = >3 cm

Range of Motion: Flexion:
1 = >90 degrees
0 = <90 degrees

Abduction:
1 = >15 degrees
0 = <15 degrees

External Rotation:
1 = >30 degrees
0 = <30 degrees

Internal Rotation:
1 = >15 degrees
0 = <15 degrees

The series of femoral allografts consists of 2 focal femoral allografts, 10 circumferential femoral allografts and 1 allograft for fusion. Construction of this bio-implant involves using the proximal metaphyseal portion of allograft tibia and 'shish-kebobing' this on a long stem prosthesis (See Figure 2 & 3). Following this it is placed within the defect providing a bone within the bone appearance.

RESULTS:

The primary aims of the use of allograft bone in hip revision surgery are the relief of pain and increased function.

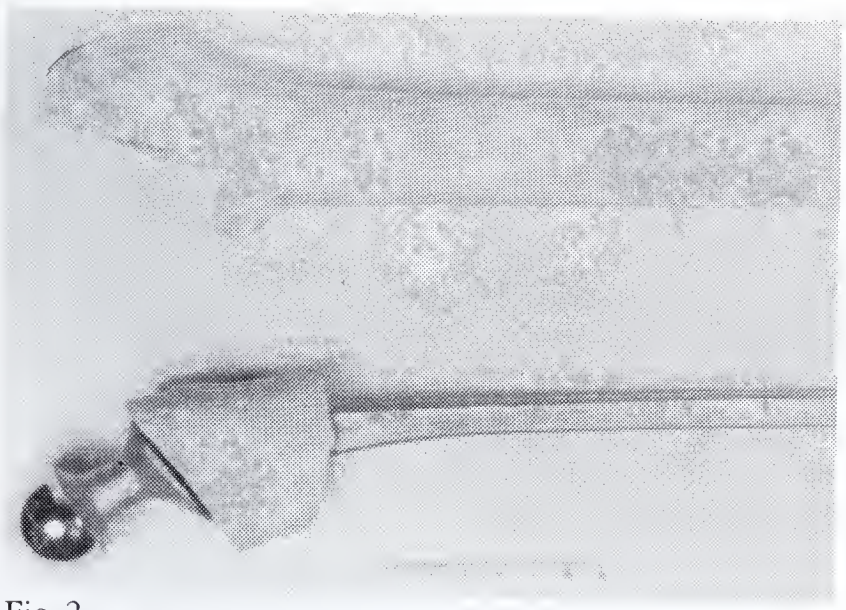

Fig. 2

Fig. 3

Pain relief was evaluated subjectively pre- and post-operatively using the protocol. (See Table II). The average pre-operative score for pain was 9.7 indicating marked pain. Post-operatively the average pain score was 40.1 out of a maximum of 44. Only 1 patient showed no improvement of pain post-operatively and this could be attributed to massive failure of a protrusio allograft. Two patients showed improvement of only one category. No patient had more pain post-operatively than pre-operatively.

A total of 46 points was awarded for function and activities of daily living. The average pre-operative rating was 13.3 and this improved to 24.7 post-operatively. Three patients were found to have lower ratings after surgery. One of these cases was the afore-mentioned failure with recurrent protrusio. The second of these cases was that of a young man who underwent allografting of a proximal femur for hip fusion after a failed hemi-arthroplasty. In this case, ability to perform some activities of daily living was sacrtificed for pain relief and longevity of the hip. In the third case, pain relief was quite marked but unfortunately again, at the cost of the ability to perform some activities of daily living and resulting in a lower score.

As can be seen from the protocol, only 10 points are awarded for deformity and range of motion. In the case of most hip surgery and especially in the case of the multiply revised total hip arthroplasty, range of motion and deformity are of secondary importance when compared to pain relief and functional ability. The average pre operative score for range of motion and deformity was 6.2. This improved to 7.9 post operatively. It is difficult to ascertain whether this improvement was as a result of pain reduction allowing increased mobility or due to an actual increase in mobility. The average residual leg length discrepancy was 1.6 cm. The fact that allografts are 'custom-built' for each appliction provides an explanation for this.

Radiographic evaluation was carried out as part of the routine follow up. Special attention was paid to evidence of loosening as demonstrated by progressive lucent lines, migration or subsidence of the prostheses. Evidence of graft resorption, fragmentation consolidation and union was also sought. The protrusio allografts were the most difficult to evaluate with regards to resorption or consolidation because of the often overlying support ring and methyl-methacrylate. However, migration in the form of progressive protrusio of the bio-implant becomes apparent as in one case of failure of a protrusio allograft in the series.

In this case, the patient was a 71 year old woman who underwent reconstruction of her right hip for protrusio using allograft and a mesh. Five years after the surgery she suffered a stress fracture of the pelvis with recurrent protrusio and dislocation of the hip. As nearly as could be ascertained, all of the other protrusio allografts appeared to be intact, with no recurrence of protrusion.

On examination of serial radiographs there were no other cases of progressive loosening. Furthermore, by the time of review, there was no evidence of resorption or non-union of any of the femoral, shelf, or the column allografts.

Complications

There were 3 dislocations, one of which has persisted as a recurrent subluxation, one superficial, and two deep infections (with persistent drainage), one pulmonary embolus, one proven deep vein thrombosis, and one fracture of the metaphysis of the ipsilateral tibia. This fracture was incurred during prepping and drapping of the patient in an extremely osteoporotic female.

CASE REPORTS:

Case 1

Figure 4 is an x-ray of a 26 year old man who suffered an intracapsular fracture of his left hip in a motor vehicle accident in 1974. Primary treatment at that time was an Austin Moore hemi-arthroplasty. He had increasing pain in the left hip from the very beginning. For the last year prior to revision surgery he had been unable to walk more than three blocks and had been unable to do his job as a janitor. On the basis of the work of Kostuik[5] it was felt that this patient would benefit from a hip fusion. A special hip fusion bio-implant was developed to accomplish this. (See Figure 5). The advantages of this bio-implant were that anatomical structures were preserved. At present, 13 months post operatively, the patient is pain free, can walk six blocks with the help of a cane. His fusion is clinically and radiologically solid.

Case 2

Figure 6 is an x-ray of a 74 year old woman with a history of juvenile rheumatoid arthritis and myasthenia gravis. She had undergone bilateral total hip arthroplasties in 1972. Unfortunately she developed loosening of protheses in both hips and became almost completely disabled by pain. There was massive osteolysis of the right proximal femur with loss of

Fig. 4

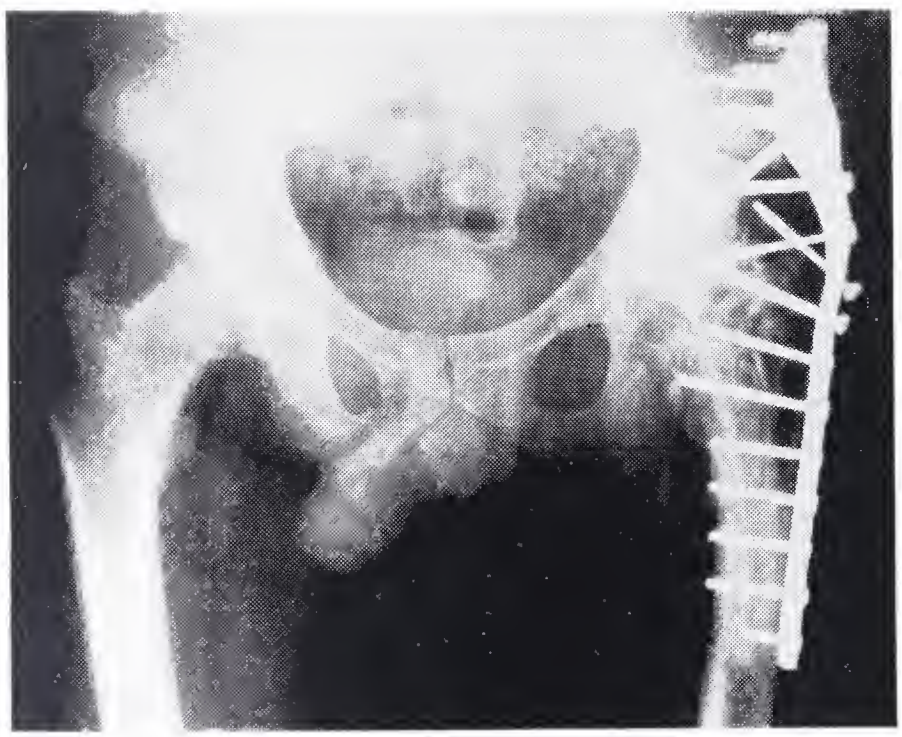

Fig. 5

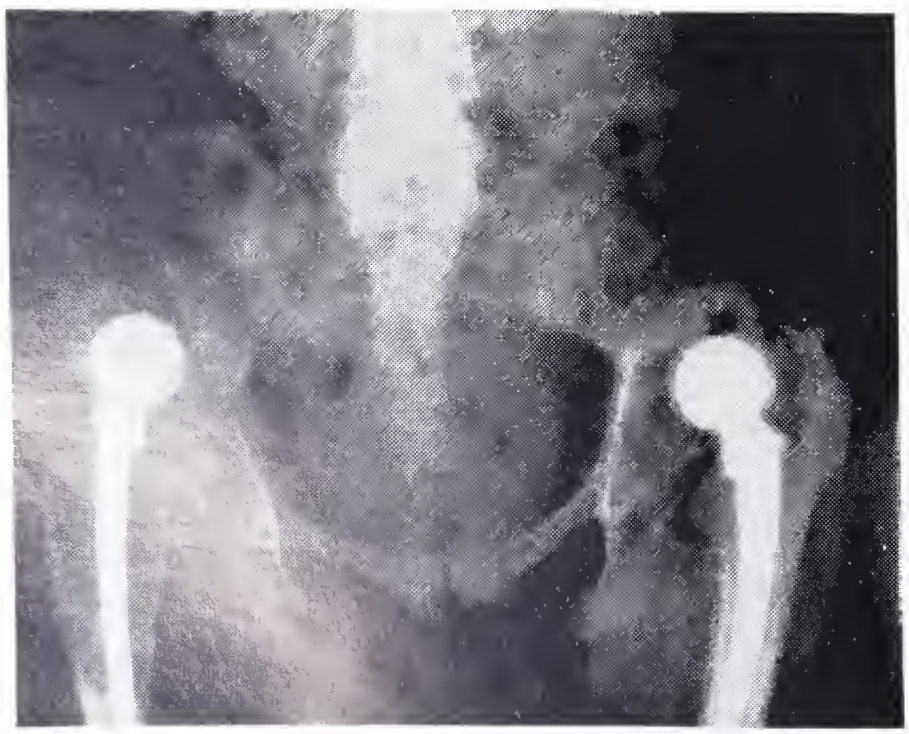

Fig. 6

the calcar on the left. There was also a marked composite type acetabular deficiency bilaterally. She underwent revision procedures for both hips eight weeks apart. (See Figure 7). A large 12 cm. circumferential allograft was used for the right proximal femur along with an allograft femoral head and Bosch-Schneider ring for the right acetabulum. On the left side the deficient calcar was replaced with a 1 cm. allograft while the deficient anterior lip of the acetabulum was reconstructed with allograft femoral head and a Mueller ring. She is now six and eight months post-operative and is ambulating without any pain or difficulty using two crutches. She will soon progress to using canes.

Fig. 7

Case 3

Figure 8 is an x-ray of a 61 year old lady who had a congenitally dislocated left hip. She underwent an innominate osteotomy of the left hip in 1964 for severe osteoarthritis secondary to dysplasia. The procedure was repeated in 1968. In 1971 a left total hip arthroplasty was performed. This arthroplasty was revised in 1981. However, due to continued bone loss on the acetabular side, the components penetrated into the pelvis and the patient become severely disabled. Radiographs on admission showed complete absence of the anterior column of the acetabulum. On January 18, 1984 a revision of the left total hip arthroplasty was performed. (See Figure 9). The anterior column of the pelvis was reconstructed using as allograft hemi-pelvis and a Bosch-Schneider reinforcement ring. This lady is now ambulating using one cane and has no pain in her left hip. She was left with 2.5 cm of shortening on the left.

Discussion:

The use of allograft bone in total hip revision surgery has been reserved for cases where other options for reconstruction are limited or less acceptable. This is particularly true in cases of proximal femoral bone stock loss. These patients were all severely disabled and faced possible excision arthroplasty. Based on the use of allograft bone in tumour surgery, and early results of this application it is felt that the use of

Fig. 8

Fig. 9

large segments of cortical allograft bone is a viable alternative. Both Chandler[2] and Harris[4] have also used allografts for this problem and although their numbers are small their results appear promising as well.

While these early results of reconstruction using allografts is encouraging, longterm follow up is essential. This is particularly true in the cases where massive allograft bone was used. These procedures are not without complications; however, none of the patients that were reviewed felt that he or she is worse than they were pre-operatively.

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The Circumcision Controversy: A Review

Dan Poenaru 8T6

"There is a Destiny that shapes our ends Rough hew them though we may."

- Anonymous

Circumcision is certainly unique amongst surgical procedures. One of the oldest operations known, it has been performed for the past 6000 years or so, and currently it is the most common type of surgery in males in the U.S. When such a popular procedure is based more on custom and religion than on the rather controversial health benefits, a heated debate is bound to arise. Medical literature alone abounds with contradictory statements and passionate rhetoric by supporters and opponents of neonatal circumcision. Between those attacking the procedure as "penile plunder" and "rape of the phallus"[14] and others claiming that the "anti-circumcision crusade" is an antiestablishment movement based on the unconscious fear of castration[4], where is the truth? Without pretending to find an answer, we will try to provide a clearer view on the subject, as it appears after several decades of debate.

Circumcision has been known since antiquity, probably being the second oldest surgical procedure. Egyptian mythology refered to it in the creation of Gods, and tomb wall drawings showed it as early as 2600 B.C.[11] In West Africa it had been practised for over 5000 years. The Jewish circumcision ritual was first mentioned in the Old Testament, while the Moslems had already practised it prior to the birth of Mohammed[24]. Non-ritualistic circumcision for medical reasons was first advocated in the U.S. in the 1870's, and it spread after the turn of the century to England, Canada and Australia[24].

Currently, circumcision is practised by some 25% of the world's population, including Jews and Moslems world wide, black Africans, Oceanians, and Caucasians in North America and Europe. The non-religious circumcision rate amongst developed nations is highest in the U.S. where it averages 85%, with over one million Americans being circumcised yearly after birth. The rate is low in the U.K., where it has precipitously dropped during the last decades to 0.5%. The lowest rate is in the Scandinavian countries, where it is only 0.02%[24]. Both Canada and Australia have rates of about 45%, and this value is slowly declining. Within Canada, the circumcision rate varies very widely among the provinces, from 2% in Newfoundland to 13% in Quebec, 50% in Ontario, and 70% in Yukon. Such differences can be probably ascribed to social and cultural factors.

Procedure and Instruments, Past and Present

Between the stone knives used by ancient Egyptians and the currently preferred Plastibell technique, many methods and instruments have been used in an attempt to simplify the operation and reduce its complications.

The Jewish religious circumcision, performed by a ritual surgeon, the "mohel", first consisted of only cutting off the tip of the prepuce with a double-edged knife — a procedure called "Milah". Then at around 100 B.C., this was changed to the more drastic "Periah" which involved ablation of the entire foreskin plus tearing of the frenulum, thus preventing any later "uncircumcision". Another compenent was added to the ritual at around 500 A.D.: the "Messisa", or sucking of the shed blood by taking the bleeding penis into the mouth[24]. Later on, the last two methods were mostly abandoned, and metal devices were invented for increasing the safety of the procedure. Examples are a flat shield used to protect the glans, the circumcision forceps, the preputome, and several patented clamps[6].

There are three currently used methods for non-ritual circumcision: free surgery, the Plastibell technique, and the Gomco clamp technique. Direct or free hand surgery involves a dorsal slit through the foreskin followed by excision of all tissue distal to the coronal sulcus. This method is used mainly in adolescent and adult circumcision. With the Gomco clamp technique, the foreskin is squeezed tightly between a metal cap protecting the glans and the rim of a hole in a metal plate, thus allowing easy removal of the foreskin once the clamp is released.

The Plastibell techniques is similar to the Gomco clamp technique, but the protective cap is made of plastic, has a urethral opening, and the squeezing is done by means of a string. The skin distal to the tie falls by itself after 5-10 days[24]. All methods use strict asepsis and anaesthesia is employed in children and adults, but rarely in newborns.

The Argument for Circumcision

Before discussing the reasons for which nonreligious cir-

cumcision is performed today, it would be interesting to mention the host of "medical" indications advocated for circumcision over the years. Philo de Alexandria gave, as early as the first century A.D., four reasons for circumcision: "It secures exemption from the severe and almost incurable malady of the prepuce called anthrax . . . it promotes the cleanliness of the whole body . . . it assimilates and makes those who are circumcised alike . . . it causes the semen to travel aright without being scattered or dropped . . ."[13]. In North America, circumcision was first used to prevent masturbation and hypersexuality, a "mild" form of treatment for these "illnesses" indeed compared to such other approaches as castration and penile amputation[24]. By 1891, a book on circumcision offered the procedure as curative or preventive of about 100 diseases, including alcoholism, asthma, epilepsy, hernia, syphilis, cholera, plague, gonorrhea, gout, masturbation, chorea, enuresis, paralysis, rectal prolapse, feeble-mindedness, rheumatism, kidney disease, tuberculosis, and lunacy![24] The short-lived Orificial Surgical Society, founded in 1890, published in its journal astonishing articles on the use of circumcision for such varied conditions as headaches, scoliosis, hip joint disease, and hydrocephalus[24]. If such claims seem outrageous today, it is noteworthy that some modern parental guidebooks recommend circumcision for peer and paternal penile identification, redundant foreskin, and even nervousness (a euphemism for masturbation?)[24].

What are the currently accepted indications for nonreligious circumcision? Warner and Strashin[25] quote five: phimosis, paraphimosis, recurrent balanitis, dyspareunia due to a short frenulum, and urinary obstruction due to a narrow foreskin opening. Phimosis is the most common such indication, but also the most controversial one in neonates and infants. It has been shown that the foreskin is fully retractable in only 4% of healthy boys at birth, and in 20% at the age of six months; but by 3 years of age, only 10% of boys have an unretractable foreskin, and almost none will have it by the age of 17[16]. Thus one must accept newborn and infant phimosis (i.e. unretractable foreskin) as physiological and normal. However, despite available data, most pediatricians do not know at what age the prepuce might normally be retracted[15], and the totally unnecessary practice of forcible retraction by the mother of the infant is commonly advised[9].

Compared to the relatively few, and uncommon, therapeutic indications for neonatal circumcision, the list of prophylactic indications is much longer. Penile hygiene is probably one of the most often quoted such indications. Indeed, the retained foreskin does normally lead to the collection of smegma, a whitish secretion made of desquamating epithelial cells. Circumcision is not superior to regular washing of the area in promoting penile hygiene, but apparently only a minority of boys practice such hygiene[25]. The answer to such evidence from opponents to circumcision is twofold: first, if circumcision is more common among the higher social classes, then socioeconomic factors rather than the physical presence or absence of the prepuce might account, at least in part, for the observed differences in hygiene[24]. Secondly, is it reasonable to cut off an organ simply because it is not easy to keep clean? Quoting Morgan:

> "Soap and water work wonders with the body's other orifices and appendages and there would seem no reason to doubt their efficacy with respect to the foreskin. The pinnae also collect dirt but removal of the external ears does not find favor as a routine measure of hygiene"[14]

Certainly an education program towards better personal hygiene is a more reasonable alternative.

Tightly bound to the hygiene issue and the "ill-fated" smegma is the debate around genital cancer and sexually-transmitted diseases (STD), both considered prophylactic indications for neonatal circumcision. Three types of cancer have been linked, by various authors, to circumcision status: penile cancer, cancer of the prostate, and cervical cancer. The evidence for all three is based on the lower rates of these cancers in Jews as compared with the general population, and on studies showing a carcinogenic effect of the smegma in rats. It was postulated that smegma acts as a chronic irritant or carcinogen eventually leading directly to squamous carcinoma of the penis, indirectly, via the urethra to prostatic carcinoma, and indirectly, via sexual contact, to cancer of the cervix. The evidence supporting the latter two types of cancer is rather weak for although prostatic cancer rates are lower in Israel than in the non-circumcising Scandinavian countries, many other non-circumcising countries have even lower rates than Israel[24]. Furthermore, no relation has been shown between circimcision status among gentiles and the incidence of prostatic cancer[10]. Similarly for cervical cancer, results are contradictory. The incidence of this cancer is certainly lower in Jewish women than in the general population, but among gentiles the circumcision status of the partner, when established by actual physical examination, had no effect on the rate of cervical cancer[22]. An alternative explanation for these results is a genetic resistence to specific types of cancer among the Jewish population.

The situation is different with penile cancer-here it seems probable that circumcision prevents the cancer, both based on the extremely rare occurence of penile cancer in Jews, and on similar studies among African, Indian, and North American populations[25]. Cancer of the penis carries a very good prognosis in the early stages, but a 50% or greater mortality if the lesion involves the corpora[25]. The prognosis is often worsened by the delay between the onset of symptoms and the point when medical advice is finally sought. But it must be kept in mind that penile cancer is very rare in the industrialized countries. In most such countries its incidence is 1-3 per 100,000 per year, which makes circumcision a rather inefficient means of prevention[18].

As a point of interest, the only study which showed a carcinogenic effect of the smegma involved insertion of smegma and a control substance into an artificially created skin tunnel on the backs of two groups of rats — a rather unnatural biological system — and strangely enough, although more tumours were found in the smegma-inoculated group, the longevity of that same group was much higher than that of the controls![24]

Herpes genitalis is the only sexually-transmitted disease which has been linked to circumcision status, based on the

finding of lower circumcision rates among herpes genitalis patients than in the general population[21]. Such an association, if present, cannot explain why the incidence of genital herpes has continuously increased in the U.S. after WWII, concomitantly with a constant increase in the rate of circumcision. The American Academy of Pediatrics states in this respect that circumcision does not protect against venereal disease[18].

As an operation on a sexual organ, circumcision raises specific sexual considerations. Removal of the foreskin leads to epithelial changes on the glans, resulting in a decrease in its sensitivity. This observation is interpreted quite differently by supporters and opponents of circumcision. Morgan regards coitus without a foreskin "like viewing a Renoir or a Van Gogh while colorblind"[14], while others point out the decreased incidence of premature ejaculation in the circumcised population[25]. Premature ejaculation is not a rare problem, and a decline in its rate would be quite welcome — but unfortunately most cases of premature ejaculation have psychologic rather than organic causes[25]. Finally, Masters and Johnson found no differences between the sensitivity of circumcised and uncircumcised penises[24].

Neonatal circumcision certainly cancels the need for later therapeutic circimcision, with its greater risks of the general anaesthesia. Significant in this respect would be the incidence of such late circumcisions. Estimates vary widely among authors, from a low 0.15%[16, 24] to a high 10%[25]. Obviously the two extremes would affect quite differently the decison-making process, and it is unfortunate that the calculated rates correlate above all with their authors' standpoints in the debate.

Another component of the pro-circumcision argument is the consideration of economic benefit. Warner and Strashin[25] compared neonatal and late circumcision costs in Canada; they concluded that routine neonatal circumcision can save about $18 million a year throughtout Canada. A significant saving indeed — unfortunately, their calculations included the costs of complications from late circumcision, but totally ignored the costs of complications from neonatal circumcision![2] Once again, the truth gets lost between the numbers.

Finally, say the advocates of neonatal circumcision, the procedure has so many contraindications, that it should not even be called "routine"[1]. Indeed, circumcision should not be performed in cases of prematurity, neonatal illness, low Apgar score, congenital anomalies (especially genital and neurological abnormalities), bleeding problems, presence of any rash, outbreaks of Staphylococcal infection in the nursery, and a history of pneumothorax or pneumomediastinum[25]. The case can be made that circumcision remains a routine procedure as long as most of the above complications only lead to postponement rather than non-completion of the operation. Another consideration is that circumcision is still inadvertently performed in contraindicated cases[5], reminding us that often the surgeon does not have the knowledge and experience expected of him.

Argument Against Circumcision

"Above all, do no harm". Circumcision, like any other surgical procedure, can be harmful, and this constitutes the basis of the anti-circumcision argument. The question of how frequent are the complications is difficult due to lack of consensus as to what constitutes a complication, as well as to differences in record-keeping. Reported rates vary from 0.2%[5] to 55%[17]! In between these extremes, most authors give values of 1% to 5%, similar to the risk of other minor surgical procedures.

The complications themselves fall into several categories: hemorrhage, infection, surgical injury, late complications, and pain and psychological trauma.

Hemorrhage is the most common risk of circumcision, and can range from slight oozing to serious blood loss requiring transfusion. In most cases the hemorrhage responds to simple hemostatic measures, and the injection of vitamin K at birth can further lower the risk of excessive bleeding[25].

Infections are not uncommon after circumcision, but most are minor and of little consequence. However, in some cases infection has resulted in significant local sequelae such as scarring, deformity, paradoxical phimosis, and the very rare Fournier's gangrene[25]. Systemic infections are also encountered, and reports exist of toxic epidermal necrolysis, hematogenous osteomyelitis, lung abscess, meningitis, and generalized sepsis following circumcision[9, 25]. Infections appear to be more common after Plastibell circumcision than after Gomco clamp circumcision[5].

The more common surgical complications are the formation of a skin bridge between the penile shaft and the glans, wound dehiscence, and denudation of the penile shaft[5, 25]. The skin bridge can lead to accumulation of smegma and bacteria, and occasionally to tethering of the erect penis with resultant pain and/or penile curvature[9, 25]. The treatment is surgical division of the bridge. There are many other surgical complications, such as lymphedema of the penile skin, cauterization burns, concealed penis, hypospadias and epispadias, urethral fistulae, amputated glans, and even necrosis and sloughing of the penis, but these tend to be very rare [9, 25].

Late complications include cysts in the circumcision line which may grow to significant proportions and/or become infected, and meatitis. Meatitis or meatal ulceration seems to occur in a large percent (10%-30%) of circumcised infants towards the end of their first year of life, and it is due to irritation of the unprotected glans by ammonia in the diapers[25]. Its significance is not clear, but some authors believe that it is a benign condition occuring not more often than balanoposthitis, its equivalent in uncircumcised children. Urinary retention has also been reported after circumcision, and it is usually due to a tight bandage[9].

The issue of pain and psychological trauma is one in which contradictory statements and personal bias prevail in the absence of clear experimental results. Some authors still believe that there simply is no pain associated with neonatal circumcision[3], others assert that, while pain does exist, it is limited to the time of the surgery[11], and due as much to

the necessary restraints during the procedure as to the surgery itself. However, data exist showing that the newborn has a somatic response to the stress of circumcision: there is increased crying, flushing, vomiting, and altered sleep patterns[25]. As for the long-term psychological effects, the issue is even less clear as the only two studies done followed very small numbers of children, and had contradictory results[25]. The psychosexual theory would certainly support the idea of long-term sequelae, but one can too easily be caught again in theories and assumptions. The fact is that we simply do not know what the psychological consequences of circumcision are.

Last among complications, what about mortality? Deaths have in fact been reported following circumcision, but their occurence is so rare that a statistical interpretation is difficult; the accepted rate of 2 per million[25] has been questioned by some, and remains only a rough estimate.

One should not forget however, that late therapeutic circumcision has its risks too; these are similar to the risks of newborn circumcision, but with the added burden of the general anaesthetic. Warner and Strashin estimated two additional anaesthetic-related fatalities per year in Canada if newborn circumcision were abandoned, a value much higher than that of the fatalities caused by the present neonatal circumcisions[25].

Another aspect of the pro-circumcision arugment is the usefulness of the prepuce. The assumption is quite natural: in the absence of any evidence that the foreskin is a vestigial organ, it most likely exists, and has been retained through evolution, for some purpose. In first place, the foreskin simply protects the more sensitive glans from irritation as well as from superficial injuries. It is also known that its interior epithelium is richly innervated, and hence possibly plays an erogenous role during coitus, when this inner skin layer becomes completely exposed[24]. Even assuming that the prepuce is a vestigial appendage, the appendix itself which typifies in man the vestigial structure causes a much higher morbidity and mortality, but routine prophylactic appendectomy is not a popular idea.

But circumcision, as the surgical solution to a set of pathological conditions, has a medical counterpart as well. How unfortunate that the medical treatment of phimosis and related conditions is either unknown or actively ignored by the North American physicians. In non-circumcising Scandinavian countries, foreskin problems are first treated medically, including hospitalization of necessary, before the more drastic surgical alternative is considered[24]. It is obviously the different health care system in these countries that accounts for the different therapeutic approach — in Scandinavia, neither the hospital nor the physician obtain any monetary gain from surgery and hopitalization, and for the patient, all health care is free. North American doctors have already acquired the reputation of "knife-happy," and circumcision was said to be the treatment for "chronic remunerative balanitis". In such a context, we should maybe re-consider when circumcision is necessary, and when it is not.

Making the Decision

It is apparent by now that such an old and popular practice as circumcision is not controlled by the state of medical knowledge alone. In fact, with the same medical literature available on both sides of the Atlantic, the circumcision rate has drastically dropped in the U.K. after WWII, while constantly increasing during that same period of time in the U.S.

There are two essential factors in the decision to circumcise or not: the parental attitude, and the attending doctor's own view. Several studies have investigated the factors influencing the parental attitude towards circumcision. It was found that most important were the parents' perceptions of hygiene, their belief in medical indications, and the circumcision status of the father and of any elder brother[12, 19, 20]. Informed consent would seem to be crucial in such a controversial issue, but data have shown that providing written and/or verbal information to mothers in the third trimester of pregnancy had little or no effect on their later decision regarding circumcision[7, 12]. Viewed in this light, the repeated reports that physicians do not discuss the matter sufficiently with their patients[8, 24] seem less significant than expected. And to make the situation even worse, we find out that the poorly-informed, refractory-to-advice parent doesn't usually know what circumcision means, and many mothers don't know whether their husbands are circumcised or not. It is surprising that 10% to 50% of women ignored their husbands' circumcision status — but what to say of the 34% of men who were in error regarding their own circumcision status?[24]

While parental information by itself is of little consequence, physicians play a significant role in the decision-making process. In fact, many parents feel that it is their doctor's role to decide about circumcision[24]. And their doctors do often decide for them, based on their own views. Hence we find that obstetricians and general practitioners tend to encourage circumcision, while pediatricians have a more neutral attitude[8, 19]. If a newborn is taken care of by an obstetrician, he is more likely to get circumcised than if in the care of a pediatrician[8, 20]. With such discrepant attitudes, maybe we should let the newborn decide for himself.

Instead of Conclusion

Summarizing the current standpoints on neonatal circumcision is useless — there are simply those that say that it should be done, and then others that say that it shouldn't. A better idea of the present state of confusion is given by a few remarks taken from various articles:

> "For the male population as a whole we recommend circumcision because of its medical and economical advantages"[25]
>
> "... 98 times out of 100 there is no valid indication for this mutilation other than religion"[14]
>
> ". . . one might recommend circumcision as prophlaxis against penile cancer in the tropics or balanitis in the desert, but in temperate, non-desert areas, its use remains ritual"[5]
>
> "... routine infant health circumcision is archaic, useless, potentially dangerous, and therefore should cease"[24]
>
> "... it is impossible to say how great or little is the value of neonatal circumcison over the entire period of a man's life"[23]

Following are the official policy statements of the American Pediatric and Obstetrical societies:

> "There is no absolute medical indication for routine circumcision of the newborn" — American Academy of Pediatrics Ad Hoc Task Force on Circumcision, 1975 (renewed in 1982)[18]
>
> "The American College of Obstetricians and Gynecologists supports the position of the AAP Ad Hoc Task Force on Circumcision" — Statement on Neonatal Circumcision, Executive Board of ACOG, 1978[24].

Here we are in 1985, unable to decide whether the most common surgical procedure in North America should, or should not, be routinely performed. The medical evidence is at best inconclusive, but mostly confusing and often contradictory, and the well-established public attitude is refractory to information campaigns. "Whither the foreskin?" — as the title of an article ran. One day the medical profession will reach a consensus on circumcision — and hopefully the public will accept it - but many a prepuce will be shed until then.

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Mediastinal Mass In A Known Cirrhotic Male

E. P. Harris-Jones, M.B. Bch, F.R.C.P. (C)
G. L. Weisbrod, M.D., F.R.C.P. (C)

Chest tomograms (Fig. 3) show a lobulated, apparently solid mediastinal mass in a retrocardiac position.

The upper GI (Fig. 4) shows the presence of large oesophageal varices.

The CT scan (Fig. 5) shows submucosal oesophageal varices with luminal narrowing (of the oesophagus). Lobulated enlargement of the oesophageal wall is also present. Massive oesophageal varices were suspected as a cause for the mass. This diagnosis was confirmed at angiography (Fig. 6,7).

The entity of mediastinal pseudotumour secondary to oesophageal varices has been well described[1 2 3]. Four cases of this entity have been seen in our department over the past five years, this patient representing the most florid example.

It will be noted from the CT scan that the bulk of the varices were situated in a subadventitial or paraoesophageal position. These veins would therefore not be subjected to the confines of the oesophageal lumen and could thus attain the massive size demonstrated in our patient.

Of interest, in this patient, is the fact that he as never experienced a variceal bleed despite the size of his varices.

He was treated conservatively. Sugical shunt procedures will be reserved for such time when and if he has a bleed.

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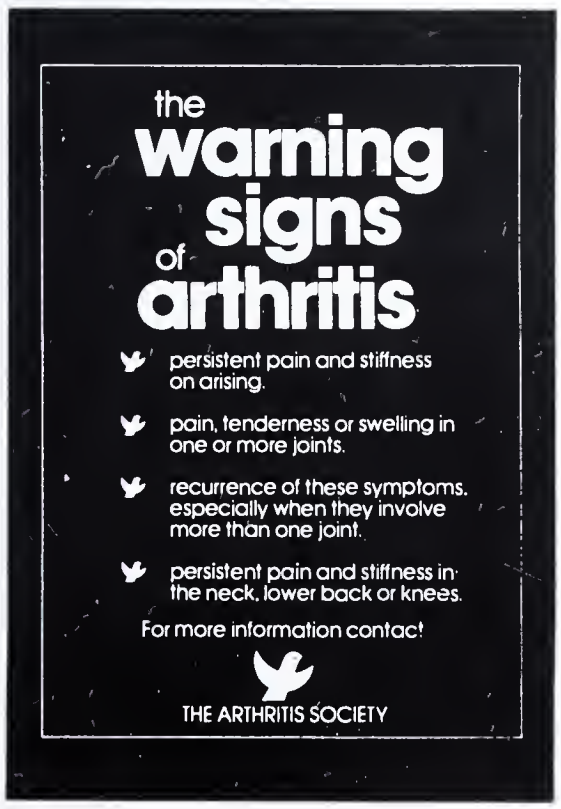
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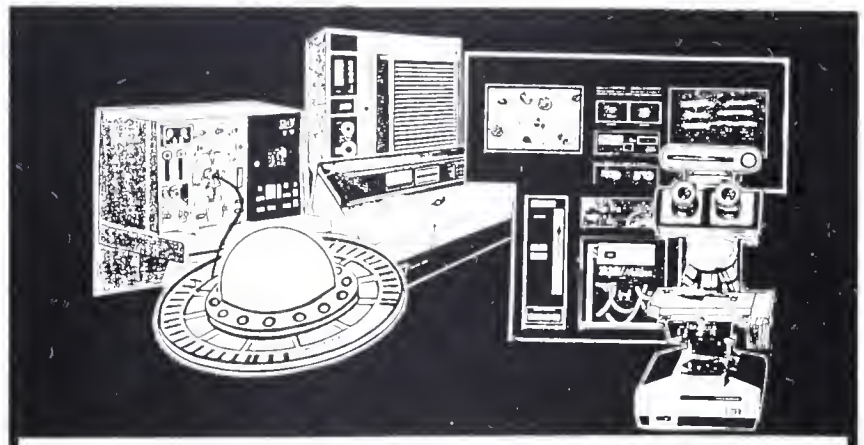

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Residential Treatment of Adolescents

Denise Sequeira 8T6

The C. M. Hincks Treatment Center, 440 Jarvis Street, Toronto has been in operation since 1967. The following paper is written to outline the adolescents; the treatment model; and the management within the unit.

Almost all societies recognize a phase between childhood and adulthood. This phase is difficult to define exactly with set boundaries but one could say that this period starts with the onset of puberty and ends when a person has adapted to the major socio-cultural expectations of society.

During this developmental process, many adjustments have to be made. The child entering adolescence undergoes biological changes and has to be able to modify their self perception appropriately. Along with this, the early adolescent would be subjected to cognitive changes. As many have said in the past, this is the period of hypothesis testing, the period during which the adolescent can formulate the pros and cons in decision making. In this way, cognition strongly connects the adolescent to their psychological development with a personal sense of identity being in the forefront.

As the adolescents see themselves as individuals, they also see themselves as part of society; in this way they need to relate to the rest of society, and form friendships and intimate relationships outside of their family.[1]

If any of these developmental processes are interrupted or slowed, the setting for an abnormally functioning adolescent may occur.

The Adolescent Referred

By the time an adolescent comes to the C. M. Hincks Treatment Center, he or she has exhibited severe disturbances in their capacity to function. This behaviour had not been correctable by child, family or out-patient methods. Their behaviour is termed maladaptive and thus has come to the attention of higher authority: family, school, police or community agencies.

The presenting problems of these adolescents fall into three broad categories:

1. behaviour against community, for example, crime
2. behaviour against self, for example, parasuicide or drug abuse
3. behaviour withdrawal from society as in schizophrenic decompensation.[2]

The program at C.M. Hincks Treatment Center serves a patient who shows evidence of psychiatric disorder as outlined by D.S.M. III, who shows a failure to function in their natural environment, and who may have a history of dangerous behaviour. Table I outlines the adolescents admitted over the last two years.[3]

Table I - In Patient Population
Jan. 1982 - Dec. 1983.[3]

Total number of patients treated	51
Average length of stay	8 months
D.S.M. III Diagnostic Group Treated	
Conduct Disorders	40%
Schizophrenia	10%
Personality Disorders	20%
Anorexia Nervosa	8%
Major Affective Disorders	14%
Obsessive Compulsive Neuroses	4%
Mental Retardation	4%

Besides having a disorder as outlined above, many adolescents admitted have concurrent physical and social handicaps. Physical handicaps include: epilepsy, blindness, deafness, learning disorders, and chronic medical afflictions. Social handicaps seen included deficits in social skills necessary to interact within society and to maintain appropriate relationships. These adolescents present a challenge because their resources for treatment are often harder to utilize.

One may ask why an adolescent has a disturbance of behaviour. There are multifactorial causes of adolescent dysfunction; these include: biochemical defects, family pathology, intrapsychic conflicts, and interpersonal conflicts.

As a result, one finds an adolescent with difficulties in trusting other people, a decreased tolerance for frustration, failure to think between instinct and action, and often concealed depression. Often these patients are not well tolerated by their families, and their families seek help for them. The adolescent in-patient's dysfunction is often interwoven with abnormal family dynamic processes and may in fact be due to family pathology or disorganization of the family unit.

The family must normally provide stability and support for the growing adolescent. There are great stresses on parents as the child undergoes detachment and achieves autonomy. These parental stresses often affect the adolescent adversely

if the parents are unable to deal with a troublesome adolescent constructively and consistently.

Often these troubled teenagers come from predisposing family settings. These include the immigrant family in which the parents may undergo intense role stress because of the parents' role expectations for their children being consistent with a totally different society. Also, in today's economic setting, with the unemployment rate soaring, one sees more and more families with economic stresses. The children in such families often have to deal with these stresses in their early adolescence. In addition to unemployment, economic stress often accompanies a single parent family. With divorce rates in Toronto being one in three marriages, adolescents are often confronted with emotional and economic stressors. Children of divorce are often torn between parents, confused by relationships, and are unable to adjust without decompensation.[4] Formal studies have confirmed the clinical recognition that adolescents are imitative of their parent's overt behaviours as well as their covert emotional responses and attitudes.[5] Thus the family plays an integral part in the adolescent's dysfunction or function in society.

Evaluation on Admission

At Hincks Treatment Center, a multiaxial diagnosis based on D.S.M. III criteria is formulated within six weeks of admission. This is supplemented by identification of primary and secondary handicaps of illness.

The primary handicaps are defined as disabilities that are part of the illness; they include problems in family, school, work or interpersonal relationships. Secondary handicaps are defined as maladaptive reactions to illness and may include identification with the sick role, dependency conflicts, suicidal tendencies, or lack of self esteem.

Premorbid handicaps and ego strengths are identified for treatment orientation. Each patient has an identified theme which forms the basis of treatment and there is a goal-oriented type of behaviour which is relayed to the patient many times throughout their stay.

Assessment on admission also includes neuropsychological evaluation, physical examination, educational assessment, family assessment and social assessment. This body of information is discussed at an assessment review conference where staff psychiatrists, child care workers, teachers, nurses, and social workers are present. A plan of treatment is made. Long term goals are made with respect to education/occupation, recreation, and family. Treatment plans are discussed and a stage of treatment identified. For staging classification, see Table II.[6]

An appropriate environment is developed for the patient and the patient begins the process of adaptation in so called stage two.

The Adolescent Unit - The Therapeutic Environment

The setting for treatment is a sixteen-bed psychiatric unit. There are nine beds for boys and seven beds for girls. The age range is from thirteen to nineteen. The staff consist of child care workers, teachers, nurses, social workers, and the director of the unit, a psychiatrist. The physical environment consists of two open wards, (boys/girls) and a closed I.C.U. used to prevent agitated patients from hurting themselves or others. The structure of the two open wards allows the exercise of autonomy with increasing privileges as time and trust progresses.[7]

Table II - Stages of Treatments[6]

Stage I	Assessment
Stage II	Stabilization on the Unit: Education, Recreation, Family access, etc.
Stage III	Movement into the Community
Stage IV	Aftercare

Marshall and Weinberg's study of adolescent in-patients describe four advantages and three disadvantages of this type of adolescent only unit as opposed to a mixed adult and adolescent ward. These disadvantages include: 1. increased sexual arousal and acting out; 2. intrusion of emotional needs of personnel and keen competition among patients for staff favour; 3. failure to clearly delineate the rules of behaviour or lines of authority and inconsistencies in dealing with rule infractions with resulting insecurity. The advantages include: 1. coping with a limited age range instead of feeling misplaced on adult wards; 2. increased fulfillment of the adolescent's needs by staff; 3. an available concurrent educational program; and 4. resocialization programs which include adolescent group therapy and family therapy.[8]

The C.M. Hincks Treatment Center has high staff to patient ratios, and includes a school program affiliated with the Board of Education guidelines. School is scheduled on a fulltime, five days a week basis and includes a full academic program as well as a vocational or life skills program.

There also exists a work project; the patients operate a small business which emphasizes social and economic skills such as marketing, accounting, and management. The group funds itself by selling shares in their cottage industry to members of the staff. They also sell their products to the public.

Recreational activities for the residents are individually and group-oriented. Activities such as music classes, sports, and evening outings to recreational facilities within the community take place. Often some patients in stage three are allowed to join in community based groups such as cadets, track and field associations, volunteer groups, as well as seeking community employment. The basis of integration of the patient into society with close supervision and support lends to the success of community integration.

Adolescents are allowed to see their families; this is determined on an individual basis with both long and immediate goals kept in mind.

Residential Treatment - The Therapeutic Model

When perusing the literature, one finds there are many definitions of residential treatment. Most definitions seem

consistent in that they do not see residential treatment as merely the removal of the child to a benign environment where they are available for psychotherapeutic interviews.[9] All facets of the resident's life are considered to be understood and treated and also the normal development of cognition and emotion must continue in an age appropriate way.[10] Thus elements of treatment and the normal development of the adolescent are both important in residential treatment.

At C.M. Hincks Treatment Center, the model of treatment is the adolescent unit itself which provides the residents with individualized treatment millieu. These treatment programs may include group therapy, individual therapy, family therapy, medications, and behaviour modification.

The adolescent program is designed to reinforce adaptive constructive behaviours and to reduce maladaptive destructive behaviours. Accordingly, the residents have an out of group system structured within their staging system (Table II). Breaking treatment rules or engaging in inappropriate behaviour such as assaultive behaviour, destruction of property, stealing, returning from running away, use of drugs, smoking on the unit, use of offensive language lead to out of group status. This status includes ward restrictions, one-to-one staff supervision, no verbal communication between resident and staff or resident and peers; also, the patient eats outside of the rest of the group and physically works on manual labour tasks. Breaking rules is an experience of failure to formalize within the millieu so a more restrictive millieu is created, for instance Stage I out of group; failure to function in Stage I leads to an even more restrictive millieu; Stage II out of group, and so on. The concept here is not punishment but loss of freedom to make judgements. As the stage becomes more restrictive, the staff become the patient's ego strengths. After this issue is resolved, the patient is replaced in their appropriate stage for treatment to continue.

The Residential Treatment Model at C.M. Hincks bases therapy on allowing the resident to function within the millieu it has created. They minimize the stresses within this environment and manipulate the therapeutic millieu as the patient progresses and is able to handle more. The basis of stage III, rehabilitation and movement into the community, are indicative of this model's concept of increasing a patient's functioning to a maximal point. Aftercare, stage IV, also acts as reinforcement of rehabilitation as the patient is maintained by aftercare workers, and may indeed come for treatment as an outpatient to the center.

Conclusion

The C.M. Hincks Treatment Center provides much needed service to the community. Although its effectiveness has not been formally evaluated, the treatment program described herein incorporates a multidisciplinary team approach. The program provides each child with a comprehensive in-depth evaluation as a foundation for an individually-tailored treatment program that offers a high level of specificity, objectivity, and accountability not ordinarily found in more traditional approaches.[11]

Acknowledgements

I would like to thank Dr. B. Kennedy, the staff, and the residents of the C.M. Hincks Treatment Center for the experience they gave me by working so closely with me. I also extend thanks to Dr. B. Kennedy, Director of the Treatment Center, for his assistance in researching this paper.

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Case Report: Investigation of a Mediastinal Mass

*Keith Philip Martin B. Sc., 8T6**

Presentation of the Case

A 76 year old woman was admitted to the hospital emergency department with cachexia and a productive cough. The cough was productive of yellow sputum of unknown amount for 2 weeks prior to admission. Severe anorexia was present for the same period of time. There was a 1 year history of progressive weight loss of unknown amount, but particularly marked in the last week (4 kg loss). Her voice had become progressively hoarse in the last few years. She denied fever, chills, night sweats, haemoptisis, or dyspnea. There was no history of TB, DM, MI, or cancer. There was a 50 pack year history of smoking. Medications on admission included Digoxin, Ampicillin, Biquin and Aldactone.

Past Illness

In 1980 she was admitted to hospital for rapid atrial fibrillation. At this time, the incidental finding of a large left perihilar mass was made on chest X-ray. Fig 1 (a) and 1 (b) (PA and lateral) show the mass with possible calcification at its inferior margin. Also shown is a marked tortuosity of the descending aorta. The patchy infiltrate in the right lower lobe is consistent with pneumonia. There is also a flattening of the diaphragm with a marked increase in the AP diameter of the chest indicating chronic obstructive lung disease.

It was believed that this mass may represent an aneurysm of the aortic arch, however, a pulmonary parenchymal mass lesion or mediastinal tumour must be excluded. In order to do this, the following investigations were undertaken:

A. Venous angiography. Fig. 2. In this procedure, a catheter was advanced from the femoral vein to the distal portion of the inferior vena cava where the contrast was injected, and films were subsequently taken. These films also showed a mass. However, a small irregularity in the aortic wall adjacent to the mass was seen. (not seen in Fig 2). This finding favours an aneurysm as opposed to a cyst since the latter does not produce defects in the thick aortic wall.

Fig 1(a) Chest X-ray: P.A.

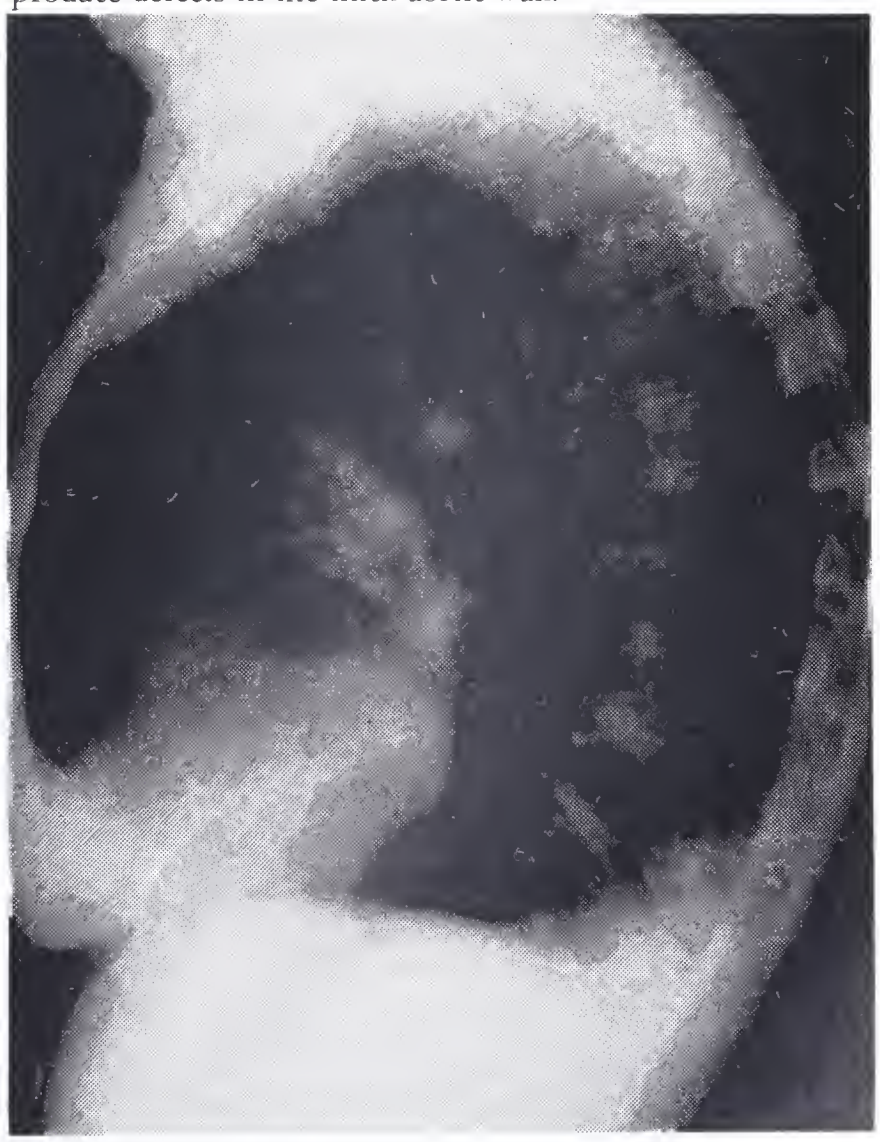

Fig 1(b) Chest X-ray: lateral

* *with grateful appreciation to Dr. S. Riche and Dr. Sanders, Dept of Pathology, Toronto General Hospital.*

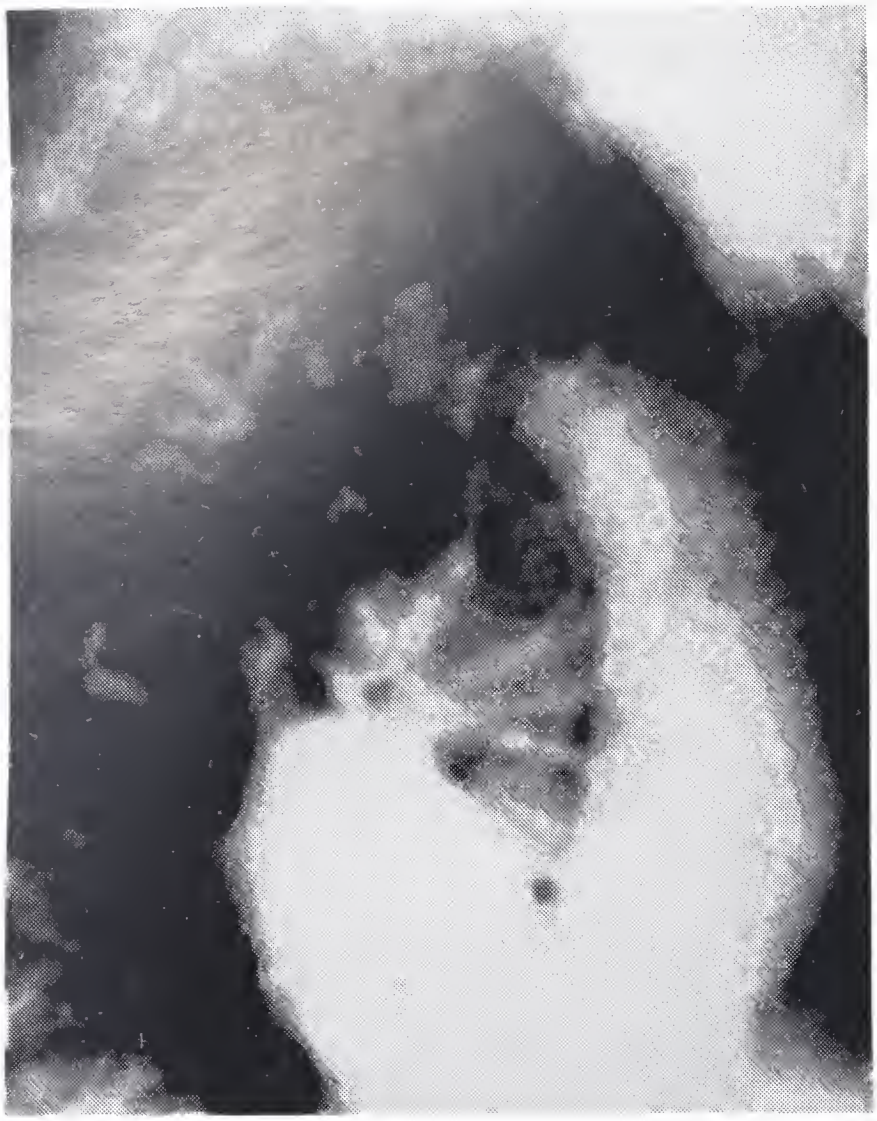

Fig 2 Venous angiogram, left lateral. this shows the left atrium with contrast, ascending aorta, arch, aneurysm and descending aorta.

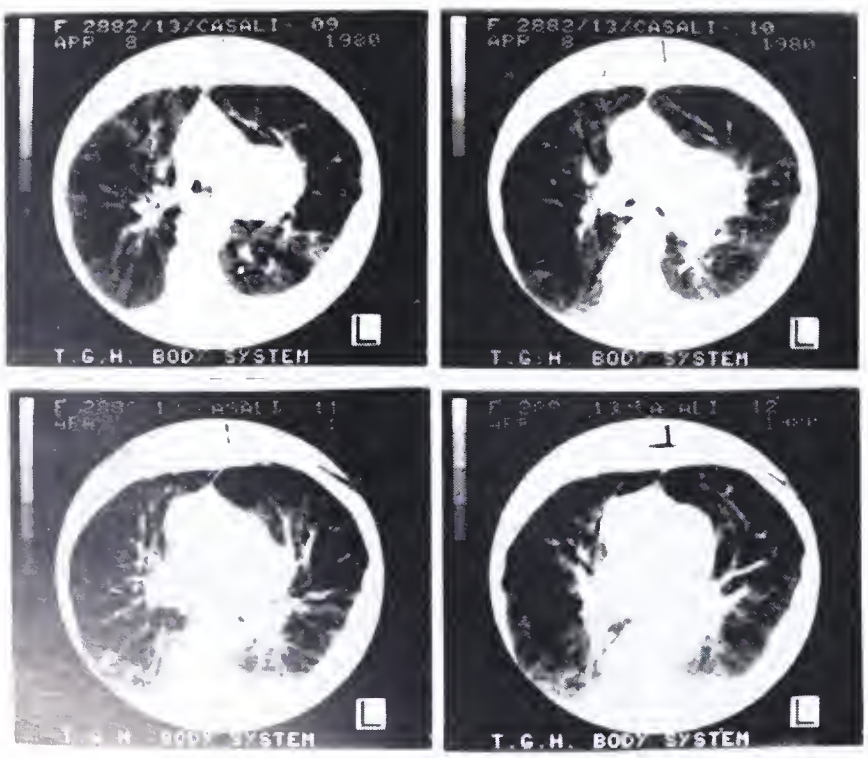

Fig 3 CT scan without contrast

B. Bronchoscopy with brushings and washings were negative.

C. Tomograms taken through the mediastinum revealed a smooth mediastinal mass with definite calcification in its wall. The presence of calcification would support the diagnosis of an aneurysm.

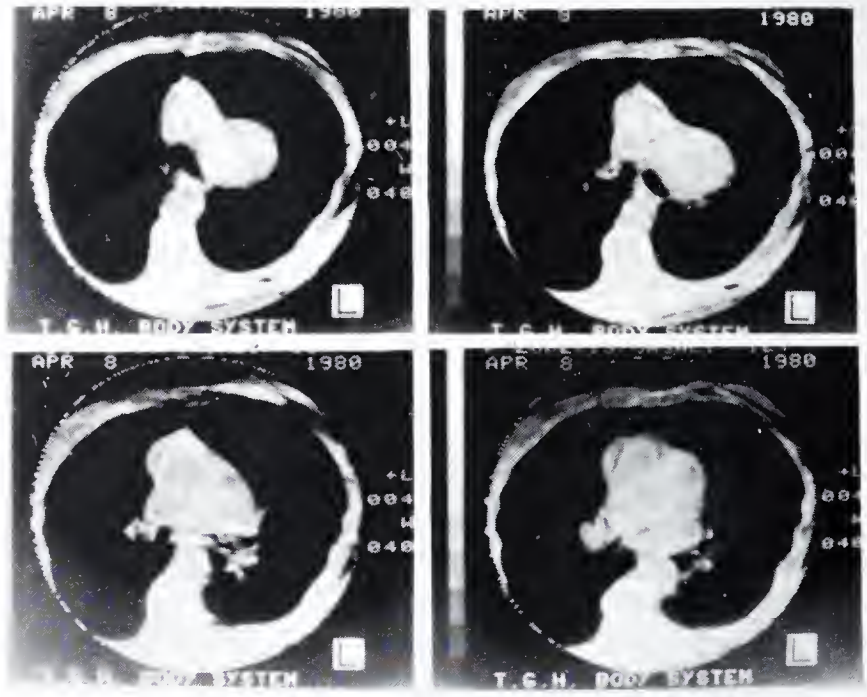

Fig 4 CT scan with contrast. Notice how clearly defined the wall of the mass is. One can also see linear calcification within the lesion.

D. CT scan of the thorax without contrast, Fig. 3 and with contrast, Fig. 4, were done. These demonstrated the same findings as the tomograms. Calcification is particularly evident with contrast.

E. Lastly, a needle biopsy of the lesion was done and this demonstrated the nonspecific findings of epithelial cells. On this basis, the medical staff diagnosed the mass as a bronchogenic cyst.

The patient was treated in 1980 for her immediate problem, the atrial fibrillation, and released.

Course in Hospital

The patient's course this most recent time in hospital was characterized by extremely rapid deterioration. She ate very little and attempts at caloric supplementation were unsuccessful. There was a marked deterioration of mental functioning with a decreased level of consciousness, disorientation, and incontinence. She had pneumonia and was treated with Pen G initially and later with ampicillin. Ventolin and digoxin were also administered.

She died 1 week after admission. The cause of death was listed as cachexia, possibly due to a pulmonary neoplasm.

Major Pathological Findings

At autopsy we had a severely cachexic woman with a weight of 21 kg. Upon exposure of the left perihilar region, we found a 6 cm x 6 cm intact, saccular aortic arch aneurysm that was compressing the surrounding lung parenchyma. Stretched across the surface of the aneurysm was the left recurrent laryngeal nerve, Fig. 5. This would explain the patient's hoarse voice.

When the aortic arch was cut, a 1 cm. x 1 cm. circular defect was found on the inferior aspect of the arch, Fig. 6.

Upon hemisecting the aneurysm we found that it was filled with a mural thrombus, Fig. 7. Also, the presence of an intact elastica on microsopy demonstrates that this was not a pseudo-aneurysm.

Angiography of the heart showed marked calcification of the right and left coronary arteries with partial occlusion of the right coronary ostium. There was also mild right ventricular hypertrophy.

Gross examination of the lungs revealed generalized centriacinar emphysema that was most severe in the upper lobes bilaterally.

The presence of bronchopneumonia in the left upper and middle lobes was evidenced by patchy consolidation of the lung parenchyma. Also tissue sections showed a suppurative exudate composed primarily of neutrophils that filled the bronchi, bronchioles and adjacent alveolar spaces. Fig. 8 shows a piece of meat in a bronchi surrounded by inflammatory cells. These findings indicate an aspiration pneumonia which was probably the ultimate cause of death on a background of inanition and severe cachexia.

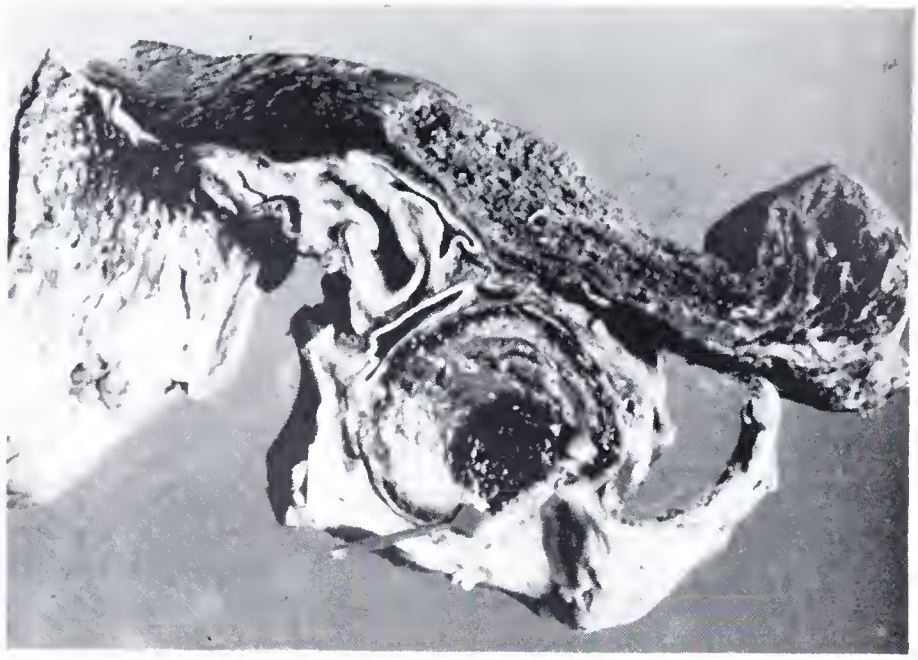

Fig 7 Aneurysms filled with mural thrombus

Fig 5 Autopsy picture of aneurysm

Fig 8 Inflammatory cells in bronchi

Fig 6 Opened aortic arch showing 1 cm + 1 cm circular defect

Discussion

The presention of an elderly person with a long history of smoking, cachexia, progressive weight loss, hoarseness and a mediastinal mass makes one instantly suspicious of a lung malignancy. In fact even without the history, the presence of a mediastinal mass by itself carried with it a 50% chance of being malignant.

In general the differential diagnosis of a mediastinal mass would include bronchogenic or tracheal tumours, bronchogenic cyst, esophageal lesions other than hernias, lymph node disease (eg. lymphoma, metastatic disease, sarcoidosis) and aortic aneurysm. In this patient our primary concerns were that we were dealing with a malignancy, cyst, or aneurysm.

The investigation of this patient included the standard PA and lateral CXR. The findings of a smooth, regular lesion with calcification in its borders strongly favours a nonmalignant lesion. A useful and inexpensive aid in differentiating a malignant from a nonmalignant lesion is acquiring a prior

CXR to see if the lesion has grown in size. If it has increased in size over time then this favours malignancy. Unfortunately, an old CXR was not available.

The negative findings on bronchoscopy decreased the possibility that we were dealing with a malignancy and favoured the presence of a cyst or an aneurysm.

In trying to establish the diagnosis of an aneurysm of the aortic arch in the presence of a negative VDRL, it is important to delve into presence of some past history of blunt trauma to the chest, eg. the deceleration type of injury one finds in motor vehicle accidents as the thorax is smashed into the steering wheel. In these cases, the aorta may sustain a linear tear. If the tear is not large, and in the presence of shock with its low blood pressure, the victim does not bleed as profusely as one might expect. Rather, the adventitia covers the tear and a traumatic pseudoaneurysm is formed. This aneurysm may become evident in the near future or may last throughout the patient's lifetime and be noticed only as an incidental finding at autopsy. In this particular case no such history was found.

Venous angiography was performed because, in general, it is an effective way of diagnosing vascular lesions of the mediastinum such as aneurysms, malformations of the aorta and vascular tumours. However where greater contrast is required and one has to differentiate between a bronchogenic cyst versus an aneurysm, a selective retrograde femoral arteriogram is indicated. In this procedure a catheter is inserted into the femoral artery and threaded up into the aorta until its tip sits in the ascending aorta.

Contrast is then released and films are taken. This procedure is far superior to the venous angiogram for assessing the presence of a filling defect in the vessel wall as the contrast is in a much higher concentration in the region of the lesion. In venous angiography, the radiopaque material is diluted through the heart and lungs before it reaches the lesion in the aorta and therefore provides much less resolution.

The needle aspiration biopsy that was done demonstrated the nonspecific finding of epithelial cells. It was on this basis that the diagnosis of bronchogenic cyst was made despite the presence of radiologic evidence to the contrary. It ought to be stressed that the needle biopsy is only suitable for the exclusion of malignancy as the results are often inconsistent with the pathology when one is dealing with nonmalignant lesions.

The CT scan is arguably the greatest radiological achievement since Professor Roentgen in 1895 discovered that there existed a form of radiation that could penetrate objects completely opaque to light. With respect to the differentiation of mediastinal lesions, CT studies are invaluable. They are particularly sensitive for recognizing calcification.

When trying to differentiate between a cyst or aneurysm it is best to do the studies first without contrast and then with contrast enhancement. In comparing the two one may be able to see a filling defect on the vessel wall which would favour an aneurysm since cysts do not demonstrate this.

In this case, the CT studies were done 4 years ago in a second generation scanner. We now have fourth generation scanners that increase our resolving power many folds. However, even with these new machines, the differentiation between an aneurysm and a cyst is difficult.

Conclusion

The presence of a mediastinal mass that may be either a bronchogenic cyst or aneurysm presents a challenging diagnostic problem. The most important tests to differentiate between these is the retrograde femoral arteriogram of the aorta and the best CT scanner you can employ. The use of needle aspiration biopsies is not particularly useful in differentiating between nonmalignant masses; although there are of course exceptions, eg. sarcoidosis. Biopsies are however very useful in ascertaining whether a lesion is malignant or not.

In closing, it is dangerous to "treat" a mediastinal mass by observation. Every effort must be made to establish a diagnosis promptly to ensure effective treatment. If the lesion is malignant, then appropriate therapy may be instituted. An aggressive approach is also warranted in the diagnosis of benign lesions of the mediastinum since life-threatening complications may occur if not treated appropriately.

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GO FAITHFULLY AMID THE DISEASED AND DISTURBED AND REMEMBER WHAT SERENITY THERE MAY BE IN HEALTH. AS FAR AS POSSIBLE WITHOUT burnout, give your best to all patients. Project your knowledge quietly and without condescension; and listen to all patients, even the dull and ignorant; they too may have an informative history to give. Avoid compulsively aggressive and over competitive peers, they are vexatious to the spirit. If you compare medicine with other careers, you may become vain and bitter; for always there will be disciplines that yield greater rewards with enormously less sacrifices. Enjoy your accomplishments as well as your hopes. Keep interested in your vocation, however discouraging situations may appear; it may be a perennial umbrella as you perambulate under the cloudy horizons of time. Exercise interest in some extra-medical affairs; for the stresses of medicine could soon exhaust your inner resources. But be careful to this end ensuring your favourite pastimes maintain their unctuous delectations; many persons strive for high ideals; and a hobby soon becomes a painful obsession. Be yourself. However, let not your standards judge those who require your help and compassion. Neither be too cynical about medicine; for in the face of all criticisms and disenchantment, its role is as solid as the age old rocks. Be humble with yourself, gracefully surrendering difficult cases for further consultation. Foster strength of spirits where heroic measures fail. But do not distress yourself with suppositions. Many anxieties are conceived from the delusion of medical infallibility. Beyond a healthful discipline, be tender with yourself. You are an intricate part of the body of medicine, no less than the bladder and bowels are essential members of the human body; you have a right to be here. And whether or not it is obvious to you, no doubt the profession is unwrapping as it should. Therefore, be at peace with God, whatever your trials and ambitions; in the flagrant bewilderment of the wards, keep peace with your soul. With all its sham, drudgery, and broken dreams, medicine is still a handsome profession. Be buoyant. Strive for felicity.

dedicated to the Class of 8T5
for the years to come
and the years that are gone by,
pleasant memories
Good luck,
and
God Bless,
One and all
Dele Davies

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Polyarteritis Nodosa: A Case Report

Murray Rosenbaum 8T5

As my staffman in internal medicine once said, "No matter how long you practice, no matter how much you tell yourself not to, once in a while, a patient comes along who you get attached to." Being a clinical clerk, young in medical experience, I was more vulnerable, more liable to get involved with a patient. Being human, one tends to like some patients more than others. Unfortunately, in medicine, one may become attached to people who have a grave prognosis, and share in the pain as these people meet their demise. Such was the case in this one experience of mine.

Mr. M. was a 76 year old man whose history dates back to 1981 when this initially healthy man presented with episodes of sudden, overwhelming fatigue, typically in mid-afternoon, followed by a fever of 39°C. The fatigue and fever would be gone upon awakening the next morning. These epidsodes would occur once every 3 months until 2 years later, when he experienced the same symptoms for 14 days straight. He was then admitted to hospital in Timmins, where he lived, and he was thought to have had a flu. A few months later, he presented with a left foot drop and right handed weakness. Again, he was investigated in Timmins and then referred to a hospital in downtown Toronto. Neurologists were somewhat baffled by this case, until a clinical immunologist became involved and requested a temporal artery biopsy. The diagnosis of giant cell arteritis was made and the patient was treated with high dose prednisone. However when the dose was tapered, the patient felt more fatigued and was sent back to Toronto. Nerve and muscle biopsies were performed and the diagnosis was revised to polyarteritis nodosa. The patient was placed on prednisone and cyclophosphamide, but over the following months, he continued to become weaker and more exhausted and was thus brought back to Toronto.

At this point, the patient was placed under the care of my medical team, and I was assigned to this man. The only known, effective treatment of this rare disease was the medication he was on. I witnessed the slow deterioration of a very friendly, intelligent man. This man quickly became my favourite patient and he was slowly losing the medical battle. What had I to offer, when I visited day to day? Could I offer him hope, a false hope? It was not uncommon, that at the end of our discussion, he would turn to me, smile, and say, "So, what's the message here, Murray, just hang in there?" "Yah, just hang in there," I would reply as I would leave. We would talk about his life up in Timmins, his career as a mining engineer, his hobby of boxing, and his dear wife.

Mr. M. spent his 52nd wedding anniversary in the hospital, while his wife remained at home in Timmins. He recalled, on that day, the trips he and his wife enjoyed each year, travelling across Canada. It seems that when all the future has to offer is pain, people tend to turn to the fond memories of the past. He would phone his wife every day and, as he put it, they would talk for an hour, just like when they were courting. On their anniversary, he called her twice. I arranged for a cake and candles to be sent to his room, with the cooperation of the head nurse. What else could I have done for this man, who no doubt saw the end of the tunnel. What was my role as a clinical doctor? I was somebody who made him smile, somebody to talk to, yet there was not much else that could have been done.

Mr. M. continued to deteriorate slowly as we increased his medication to no avail. I was watching a house burn down, but there was not a thing in the world I could do to stop it. Being on high dose immunosuppressants, he was very susceptible to infection. One day, he developed a fever. Within 2 short hours, Mr. M. was transformed from an alert, lively, intelligent man, to an obtunded, non-responsive victim of *Listeria* meningitis. I called his wife to come down from Timmins, and his son in Toronto. I always wanted to meet his wife, but not under these circumstances. There was no hiding the fact that the situation was serious, and it was difficult to try and lower the weight as softly as I could.

Mrs. M. was just as I had imagined her to be; a wonderful, intelligent, graceful lady. She herself, suffering from congestive heart failure, handled the situation extremely well. It broke my heart, as I watched her hold her husband's hand, kiss him on the forehead, and call into his ear, " Short, Short, it's me, your little cookie. Short, can you hear me? Short? Short?" as she would just barely hold back the tears while her voice quivered. The love shared between them for 52 years was plain to see. Fortunately, the patient's daughter-in-law was always with Mrs. M. for support.

My favourite patient was now seen by the nurses in the ACU (acute care unit) as a poor, old, 76 year old who was "out of it" with a rare form of meningitis. Yet, Mr. M., being the fighter he was, didn't give up. One day, while I was visiting him, he responded to me by nodding his head and saying, "Yes". Mrs. M. was so overjoyed—her Shorty had just won the war.

After recovering to the degree of being fully alert, yet extremely exhausted, after climbing out of the deep valley, again infection struck. Shorty was in the ring, getting beaten to the ground by his opponent, and when he just got up off the floor, his opponent flashed him a solid left hook. This time it was *Pneumocystis carinii* pneumonia.

Mr. M. was transferred to the ICU, put on a ventilator with 90% oxygen and was barely surviving. His level of conscious-

ness then fell to nil. The fighter had lost his fight. The family realized it was only a matter of time, and again, after going through it all with my friend, what could I, the clerk, offer to them? This time there was no hope, no chance, nothing. He finally succumbed to disseminated aspergillosis.

After Mr. M. died, I was in a room with only Mrs. M., the son and daughter-in-law. All along, I felt helpless, that I could do so little. Yet, in the end, by talking to them, explaining, answering questions, we all knew that I and the team had done them and Mr. M. a great service.

Murray Rosenbaum 8T5

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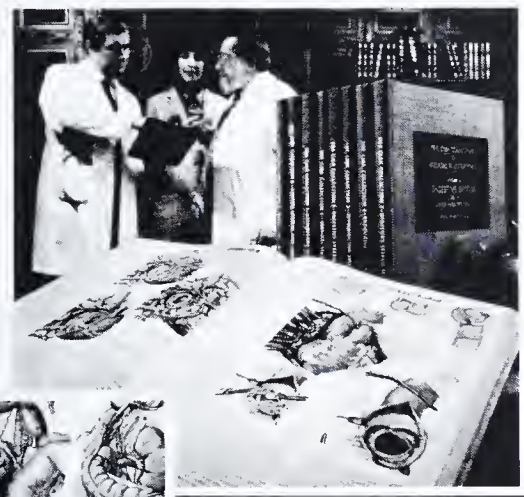

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